USDA

United States Department of Agriculture

CARIBOU-TARGHEE NATIONAL FOREST

MID-LEVEL EXISTING VEGETATION CLASSIFICATION AND MAPPING

CARIBOU-TARGHEE NATIONAL FOREST

Forest Service

Intermountain Region

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Table of Contents

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Executive Summary

Existing vegetation classification, mapping, and quantitative inventory products for the Caribou-Targhee National Forest and the Curlew National Grasslands (Caribou-Targhee NF) were developed to help the Forest better understand the vegetation types, structural classes, and canopy cover distributions at a Forest-wide extent. These products were developed in a collaborative effort involving the Caribou-Targhee NF, Remote Sensing Applications Center (RSAC), Intermountain Regional Office (RO), and the Interior West Forest Inventory and Analysis (IWFIA) program. Final map products align with the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2014 in press). The vegetation maps comprise 27 vegetation types, nine canopy cover classes, and six tree size classes. An accuracy assessment was completed to help users quantify the reliability of the map products and support management decisions that use this information. The existing vegetation products discussed in this document will help the Forest and users to better understand the extent and distribution of vegetation characteristics for mid-level planning purposes, and disclose the methods and accuracies of those products. The Caribou-Targhee NF's mid-level existing vegetation project is among several such projects currently being completed in the Intermountain Region.

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Introduction

Existing vegetation classification, inventory, and mapping was completed on about three million acres of the Caribou-Targhee NF in eastern Idaho to standards established by the Intermountain Region Vegetation Classification, Mapping, and Quantitative Inventory (VCMQ) team and outlined in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2014 in press). The purpose of the project was to provide up-to-date and more complete information about vegetative communities, structure, and patterns across the Caribou-Targhee NF landscape. Fulfilling this purpose was important in measuring compliance with National Forest Management Act (NFMA) obligations such as providing for a diversity of vegetation and associated habitat for terrestrial wildlife species. This document is an overview of the methods, products, and results of classification, inventory, mapping, and accuracy assessment activities that have been completed for the Caribou-Targhee NF.

Some management applications of the existing vegetation products may include ecosystem and wildlife habitat assessments, rangeland and watershed assessments, fuel load assessments, benchmark analysis, range allotment management plan updates, threatened and endangered species modeling, and recreation management.

Region 4 VCMQ Objectives

The Intermountain Region (Region 4) has identified the development of vegetation map products and associated inventory and classification work as one of its highest priorities since 2008. The goal of this effort has been to facilitate sustaining or restoring the integrity, biodiversity, and productivity of ecosystems within the Region by providing a sound ecological understanding of plant communities, their composition and structure. Specific goals are to:

i. Help our forests continue to manage the lands according to their land management plans
ii. Provide the public with an initial classification, inventory and map of mid-level existing vegetation in the Intermountain Region
iii. Establish a baseline of landscape ecological conditions, including vegetation type, tree size, and canopy cover distributions and locations throughout the Region

iv. Establish consistent methodologies and standardized data that meet best available science requirements, eliminate redundancies, leverage consistency, save money, and establish a framework for future activities
v. Develop scientifically credible products that meet business requirements at multiple scales and for multiple purposes
vi. Develop an update and maintenance program to ensure decisions are made on the best available information

Intended Uses

The products discussed in this document can be used to address a variety of important land management issues related to watersheds, forest characteristics, rangelands, fuel loads and wildlife habitat. Feasible applications include resource and ecosystem assessments, modeling species habitat, conducting benchmark analysis, designing monitoring procedures, or a variety of other natural resource analysis applications. Specifically for the Caribou-Targhee NF, the products will be useful for management decisions such as the Targhee forest plan lynx amendment, and the Targhee forest plan old growth/snags/cavity nester amendment. These products may also provide information for targeting areas requiring investigation for potential projects or determining where more detailed studies are needed. Additionally, data collected during this effort may feed into broader-level analyses, such as determining estimates of nation-wide biomass or land cover mapping efforts.

Business Needs Requirements

The development of existing vegetation classification, inventory and map products is at the heart of our Agency's mission http://www.fs.fed.us/aboutus/mission.shtml "...to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations". In particular, this effort focuses on "developing and providing scientific and technical knowledge aimed at improving our capability to protect, manage, and use forests and rangelands, and addresses two of the guiding principles: "...an ecological approach to the multiple-use management", and " ...use the best scientific knowledge in making decisions and select the most appropriate technologies in the management of resources".

More recent Forest Service initiatives strengthen the need for acquiring existing vegetation information for our Forests and Grasslands. The National Forest System Land Management Planning Rule (36 CFR Part 219) Subpart A—National Forest System Land was published in the Federal Register on April 9, 2012, and it became effective 30 days following the publication date on May 9, 2012. The new planning rule establishes “ecological sustainability” as a primary objective in forest management, and addresses “conservation of water flow and assurance of a continuous supply of timber set out in the Organic Act, and the five objectives listed in the Multiple-Use Sustained Yield Act of 1960 (Public Law 86-517); outdoor recreation, range, timber, watershed, and wildlife and fish”.

Included in the new planning rule regulations, the plan monitoring program addresses the applicability of eight requirements per 36 CFR 219.12(a) (5). The Caribou-Targhee NF’s existing vegetation effort addresses three of the eight plan monitoring program requirements; 1) the status of select watershed conditions; 2) the status of select ecological conditions including key characteristics of terrestrial and aquatic ecosystems, and 3) the status of a select set of the ecological conditions required under §219.9 to contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern.

The 2012 planning rule also requires the responsible official to use the “best available scientific information” (BASI) to inform the assessment, the development of the plan (including plan components), and the monitoring program. It requires that responsible officials document how the best available scientific information was used.

More recently, the Forest Service has developed a draft strategy for inventory, monitoring, and assessment (IM&A) activities as directed in the Forest Service Manual (FSM-1940). The strategy establishes a comprehensive approach for conducting IM&A activities in the agency that responds to our priority business requirements. Of particular note, the draft IM&A strategy lists existing vegetation as a sidebar for the draft IM&A strategy, and includes the statement “Existing vegetation, for example, is the primary natural resource managed by the Forest Service and is the resource on which the agency spends the most money for inventories and assessments” (USDA Forest Service, July 8, 2013).

The Caribou-Targhee NF existing vegetation mapping project attempts to meet the requirements, policy, and guidelines for properly managing our Forests through standardized protocol development and implementation, data standardization, reliable data processing, defensible methodologies, and full disclosure. These policy, guidelines and requirements establish the collection of existing vegetation information and mapping products as a requisite to proper land management in the area.

General Characteristics of the Area

The Intermountain Region of the Forest Service encompasses nearly 34-million acres of National Forest System. This region contains twelve Forests in the states of Idaho, Utah, Nevada and Wyoming, where four major geographic provinces come together (Great Basin, Colorado Plateau, Northern Rocky Mountains, and Middle Rocky Mountains). This geographic diversity is one reason for the Region's variety of ecosystems and landscapes. The Intermountain Regional Office in Ogden, Utah provides administrative support for the Region's National Forests and Grasslands.

The Caribou-Targhee NF is located in Southeast Idaho and Western Wyoming. The Forest Headquarters is located in Idaho Falls, Idaho. The Caribou-Targhee NF administers approximately three-million acres of land, including the Curlew National Grassland. There are two designated wilderness areas located in the easternmost sections of the Caribou-Targhee NF. The Jedediah Smith Wilderness is known for karst limestone formations and caves while the Wineger Hole Wilderness was primarily set aside to protect prime grizzly bear habitat. The Caribou-Targhee NF is part of the Greater Yellowstone Ecosystem.

Vegetation Mapping Areas

The study area for this effort was partitioned into ecologically unique and distinct areas based on the Caribou-Targhee NF subsections as defined and delineated for the Forest Land Management Plan, and based on the National Hierarchy of Ecological Units (Cleland et al 1997). The stratification into distinct geographic areas facilitated several processes and increased project efficiency and computer modeling. Ecologic parameters such as topography, climate, age, geology, and landforms provide abiotic criteria, while factors such as vegetation indices, spectral reflectance, and legacy inventory data provide valuable biotic parameters. Five "geographic areas" (GAs) were selected to best meet the project requirements (Figure 1).

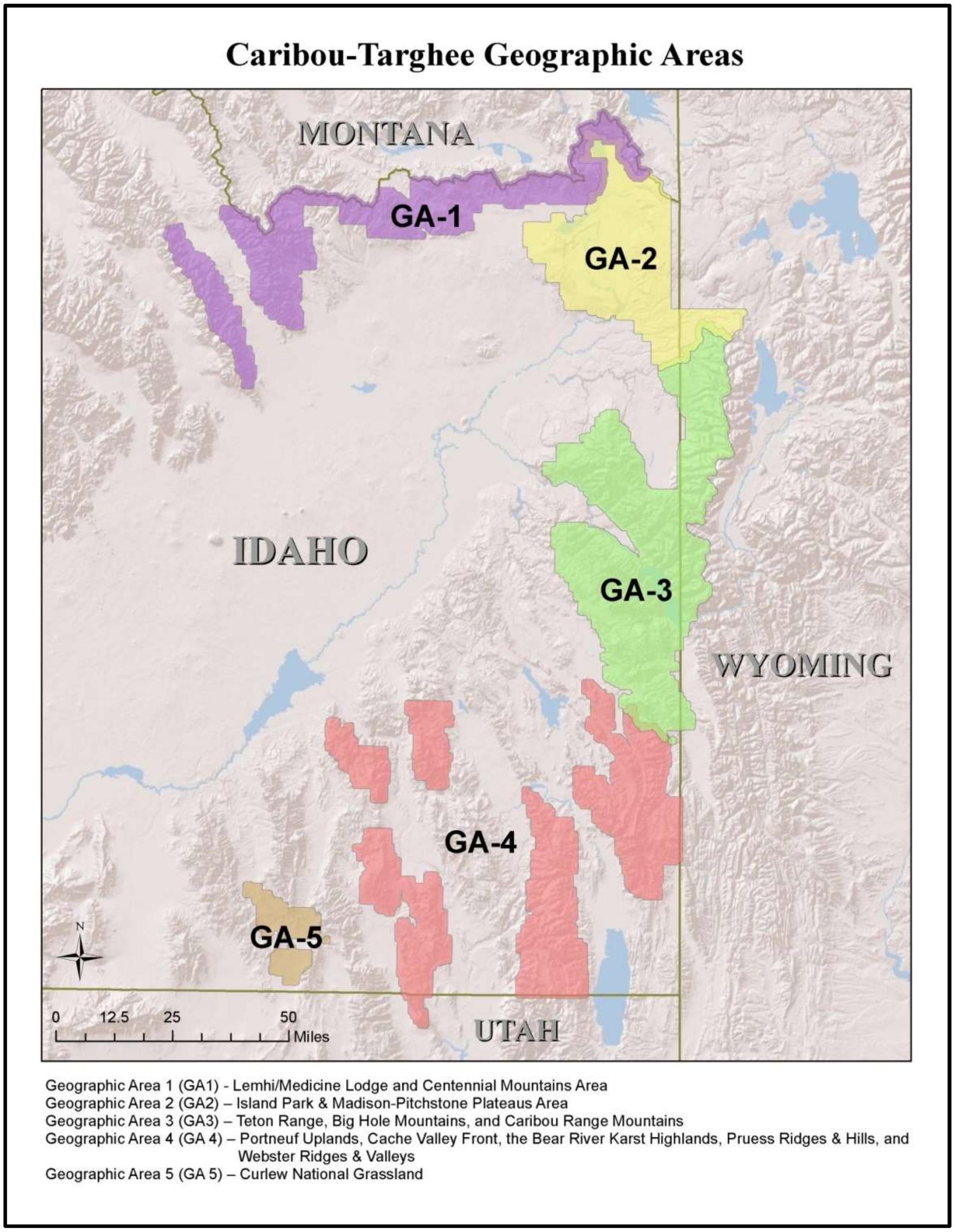

Figure 1: The Caribou-Targhee National Forest spans southeastern Idaho into western Wyoming. The area was divided into five geographic areas (GAs) to facilitate the mapping process as well as to separate unique ecological areas for modeling.

While the ecosystems of these areas are distinct, their associated elevations and climates have considerable overlap. Elevations range from 2,500 feet (above sea level) in the lower landscape positions of GA1 and GA2, to 13,000 feet on mountaintops of GA2. Due to its small size and subdued topography, GA5 has the least range in elevation. The greatest elevation ranges are in areas with rugged mountains, such as those found in GA1, GA2, GA3, and GA4, where local relief can be as much as 11,500 feet (Table 1).

Table 1: Five geographic areas (GAs) were defined for the existing vegetation mapping portion of the project with elevations ranging from 2500 ft. to over 13,000 ft.

Elevation (Above Sea Level)			
GA	**Name**	**Min (ft)**	**Max (ft)**
1	Lemhi/Medicine Lodge and Centennial Mountains Area	2,500	10,000
2	Island Park & Madison-Pitchstone Plateaus Area	2,500	13,000
3	Teton Range, Big Hole Mountains, and Caribou Range Mountains Area	5,600	9,800
4	Portneuf Uplands, Cache Valley Front, the Bear River Karst Highlands, Pruess Ridges & Hills, and Webster Ridges & Valleys Area	4,500	9,957
5	Curlew National Grasslands Area	5,135	7,500

Precipitation and temperatures also vary greatly across the geographic areas (Table 2). Most precipitation throughout the Caribou-Targhee NF occurs during the fall, winter, and spring, and mostly as snow in areas above 6,000 feet. Mean annual precipitation ranges from 16 inches on the Curlew National Grassland, to 32.7 inches in the northern areas of GA2. Prevailing winds, and the general north-south orientation of the mountain ranges, influences the climate. Summers are dry with low humidity.

Temperatures are cooler in the northern districts than in the southern districts because of the effect of latitude, and at higher elevations in all areas, with mean annual air temperature decreases of about 3.0 degrees F per 1,000 feet increase in elevation. Annual temperatures average 36.5°F to 45°F, but may be as high as 57.9 °F at lower elevations or latitudes. The growing season lasts 80 to 120 days**.**

Table 2: Precipitation and temperatures for the five geographic areas (GAs) Caribou-Targhee National Forest

Precipitation (Inches per year)					Average Temp (Degrees F)		
GA	**MIN**	**MAX**	**RANGE**	**MEAN**	**MIN**	**MAX**	**MEAN**
1	13.7	72.7	59.0	25.5	25.5	47.4	36.5
2	20.6	69.0	48.4	32.7	23.5	50.8	37.2
3	16.0	65.9	49.9	30.3	26.1	50.5	38.3
4	15.4	53.1	37.7	30.4	28.6	52.2	40.4
5	13.3	18.4	5.1	16.0	32.0	57.9	45.0

Geographic Mapping Area Descriptions

Geographic Area 1 (GA1) – Lemhi/Medicine Lodge and Centennial Mountains Area

Geographic Area (GA1) includes the Lemhi, Beaverhead and Centennial Mountains. These mountains are a result of uplifting and normal faulting forming high relief mountain ranges. This area contains high, steep mountains that are complex with sharp alpine ridges and cirques at higher elevations. It also includes valleys, and alluvial terraces and flood plains.

The Lemhi/Medicine Lodge area is rich in mining history, with old mining sites and mining towns scattered throughout the area. There are four preserved brick adobe charcoal kilns built to furnish charcoal to the Nicholia Mine in Birch Creek Valley. The most substantial Native American cultural sites on the Forest are located in this area, as well as the Continental Divide National Scenic Trail and two recommended wildernesses (Diamond Peak and Italian Peaks).

The Centennial Mountains, in the northeastern part of the geographic area represent a rare east to west striking range in the Rocky Mountains. This scenic mountain range includes high mountain meadows scattered among spruce/fir and Douglas-fir forests, and includes white bark pine trees that are an important food source for grizzly bears. The Continental Divide runs along the mountain summits, with tributaries draining to the north into the Missouri River system, and to the south into the Columbia River system. This area has seen substantial timber management activities due to the abundance of Douglas-fir. The area provides numerous recreational activities such as fishing, hiking, snowshoeing, and snowmobiling.

Geographic Area 2 (GA2) – Island Park and Madison-Pitchstone Plateaus Area

Geographic area 2 is comprised of the Island Park Tablelands and the Madison-Pitchstone Plateaus. This area has a variety of environments that include a large, volcanic caldera, part of Yellowstone National Park, and the Jedediah Smith Wilderness.

The Island Park area includes the west half of Island Park District, and the north dissected tablelands portion of Teton Basin Ranger District (Jackpine Loop). A large volcanic caldera is the dominant landscape feature. The caldera was formed as Yellowstone volcanic activity erupted throughout the area over the past 2.1 million years. The rhyolite and basalt tablelands consist of weathered rock overlain by loess. The Upper and Lower Mesa Falls, the last major undisturbed falls on the Columbia River system, are located within this area. The caldera rim landscape is on the foothills, mountains, and dissected escarpments, forming a buttress highland near the caldera perimeter.

There has been a significant influx of year-round residents in private lands adjacent to the Forest. This influx is expected to continue, due to Island Park being nationally known for its many snowmobile and cross-country ski trails. The urban interface is a growing concern for the Forest. A small portion of the Winegar Hole Wilderness lies along the eastern border of the Island Park subsection.

Forested areas are primarily lodgepole pine with smaller pockets of aspen, sagebrush/grass, grass meadows and mountain brush. Douglas-fir and mixed lodgepole pine/Douglas-fir cover types provide some diversity in the area. The floor of the Island Park Caldera is occupied with lodgepole pine and the caldera rim with Douglas-fir cover types. The caldera rim also contains aspen and sagebrush areas. The primary natural disturbance processes are fire, insects, disease, and wind throw. Mature Douglas-fir trees from the caldera rim have experienced outbreaks of spruce budworm and Douglas-fir beetle in the past decade. These infestations have subsided, but could recur if climate change continues at the projected rates.

The Madison Plateau subsection’s largest portion lies within Yellowstone National Park. This subsection is a plateau with multiple layers of volcanic rocks that have been modified by river incision and erosion. The geology is dominantly extrusive igneous rocks (basalt, lava, tephra, ash). The plateau is managed by the Ashton/Island Park Ranger District. Lodgepole pine is the most common forest cover type, with mixed stands of lodgepole pine and Douglas-fir across the remaining forested area. There are minor amounts of aspen and various mixed conifers that provide some diversity. There are many wet meadows and small lakes that are intermingled with the forests on the southern portion of the subsection, where glaciation occurred. The 1988 North Fork Fire scorched 17,700 acres in the northern part of this area.

Geographic Area 3 (GA3) – Teton Range, Big Hole Mountains, and Caribou Range Mountains Area

Geographic Area 3 includes the Teton Range, Big Hole Mountains and Caribou Range Mountains. The landscape of the Teton Range is a diverse mix of forested and open vegetation that includes Douglas-fir, lodgepole pine and mixed conifers. Grass/forb meadows and sagebrush are also common within this extent. There are a number of valleys throughout this area that have perennial streams that run through them.

The Teton Range part of this geographic area is distinguished by rugged high mountains and associated lower elevation mountains and foothills. The area has been subjected to intense glaciation and scouring at high elevations. The geology is mostly sedimentary rocks that have been uplifted along the western fault block of the Teton fault in Jackson Hole, Wyoming. Two world-class alpine ski resorts and numerous backcountry ski opportunities are located in this popular setting.

The Teton Range has a diverse mix of forested and open vegetation, including Douglas-fir, lodgepole pine and mixed conifer forests, with mountain brush, aspen, and sagebrush pockets. In some stands, aspen is being encroached upon by conifers as succession proceeds, and the amount of aspen decline has increased compared with historic levels. Mixed conifer forests characterize the upper elevations along with open grass/forb meadows and talus slopes. Since most of this area is designated wilderness, timber harvest has been limited.

The Big Hole Mountains are low-relief rolling mountains and steeper block-faulted mountains with associated foothills. The mountains were formed by multiple, parallel thrust faulting of sedimentary origin. Vegetation in the Big Hole Mountains area includes Douglas-fir and lodgepole pine forested areas with mountain brush, aspen, grass/forb openings, and sagebrush steppe. South slopes are predominantly shrublands including mountain mahogany, hawthorn, chokecherry, serviceberry, antelope bitterbrush, and Rocky Mountain maple depending on elevation.

The Caribou Range overthrust area is another thrust-faulted mountain range that consists of the Caribou, Black, and Little Elk Mountains, located in the Salt River Basin of Southeast

Idaho. This area consists of mountain ranges and valleys of primarily sedimentary rock such as limestone, siltstone, and sandstone that have been modified by erosion, terrace development, landslides, and drainage incision. Major vegetation types include subalpine pine and Douglas-fir forests, sagebrush shrublands in upland areas, and riparian types along valley bottoms. Snowmobiling and hunting are popular in this area.

Geographic Area 4 (GA4) – Portneuf Uplands, Cache Valley Front, Bear River Karst Highlands, Pruess Ridges & Hills, and Webster Ridges & Valleys Area

Geographic Area 4 covers vast areas of the Portneuf Uplands, Cache Valley Front, Bear River Karst Highlands, Pruess Ridges and Hills, and Webster Ridges and Valleys. This large expanse is mostly mountainous, with narrow valleys with perennial streams. The landscape is slightly to moderately dissected with various geologic features such as glaciated mountains with steep foothills and narrow valleys carved from dolomite, siltstone, quartzite, limestone, sandstone or mudstone. Where limestone occurs, karst topography is present, where dissolution occurred. Many valleys have been modified by natural processes such as glaciation and incision. The vegetation mostly consists of coniferous forests and shrublands.

The Portneuf Upland portion of GA 4 consists of high mountains together with narrow valleys and steep foothills formed from limestone, dolomite and quartzite. The winter months are when the most precipitation occurs with about half of the precipitation falling as snow. The landscape is moderately dissected with perennial streams flowing through the relatively narrow valleys, which may contain isolated wetlands along streams and associated alluvial deposits. Vegetation is Douglas-fir forests with sagebrush shrublands, and some aspen stands. The natural disturbance processes are fire, insects, and disease, flooding in drainage ways, wind throw and mass failures. Human-caused disturbances include timber harvest, recreation activities and grazing. This area is generally wetter and colder than the surrounding areas.

The Cache Valley Front subsection consists of very steep mountain faces, with slopes generally greater than 50%, encompassing the west face of the Bear River Mountain Range. These steep mountains were formed from dolomite, limestone, sandstone, mudstone, tuffaceous sediments and quartzite that have been modified by karst solution processes, periglaciation and glaciation. Large valleys dissect the front. Forests in this area range from woodland types such as oak, maple, and mountain mahogany to Douglas-fir and spruce-fir types. Rangelands are mostly sagebrush. The natural disturbances are fire, insects, disease and windthrow. Human-caused disturbances include fires, grazing, power lines, roads, recreational development and logging.

The Bear River Karst Highlands consists of glaciated mountains, canyons, broad basins, meadows and foothills formed from limestone, dolomite, and quartzite. The karst topography is due to dissolution of carbonates in limestone and dolomite. Many landforms have been modified by natural causes such as periglaciation, fluvial processes, and glaciation. Coniferous forests are mostly Douglas-fir, with areas of spruce-fir on north aspects, and at higher elevations. Shrublands are typically oak, mountain mahogany, and maple. Fire, flooding, insects, disease and windthrow are all natural disturbance processes that occur in this area. Historically, fires have recurred every 20-30 years.

The Pruess Ridges and Hills consist of ridges, rolling hills, and short narrow valleys that have been modified by erosion, and dissected by streams. Underlying geologic strata are limestone, conglomerate, sandstone, siltstone, and dolomite from the Mesozoic Era. Sagebrush is the major rangeland vegetation, with Douglas- fir dominating the forested land. This area contains wetlands, which includes the Elk Valley Marsh area, associated with vegetation and depositional materials. The natural disturbance processes are fire, insects and disease, flooding, and windthrow. Human-caused disturbances include logging, grazing and recreational activities. Phosphate mining is an industrial practice in this area, and supplies phosphate for fertilizers and a variety of other uses.

The Webster Ridges and Valleys area were formed from the relatively young Paleozoic to Mesozoic age sedimentary rocks, such as limestone, siltstone, conglomerate, chert, and sandstone that have been subjected to erosion, faulting, and mass-wasting. This area divides the Salt and Blackfoot River Basins. Most valleys and canyons contain perennial streams and rivers. These mountains have lodgepole pine, Douglas-fir, and subalpine fir forests, with sagebrush shrublands in openings and on escarpments. Precipitation mostly occurs as falling as snow during the winter and spring seasons. Phosphate mining is a significant human disturbance, with logging, recreation, and grazing also present.

Geographic Area 5 (GA5) – Curlew National Grassland Area

Geographic Area 5 is the Curlew National Grassland which consists of rolling hills, broad valleys, and alluvial terraces that are now predominantly used for livestock grazing since alteration by farming practices was stopped in the 1930’s. The Grassland mostly consists of shrub-steppe vegetation, predominantly covered with sagebrush and non-native seeded grasses. In the early 1900’s, over 35,500 acres of native range was cultivated and farmed.

Historically, the Soil Conservation Service planted bulbous bluegrass, crested wheatgrass, and alfalfa to reduce soil erosion and to increase forage production for cattle. A small portion of the grassland contains and supports mountain brush habitat types. A variety of herbaceous understory species provides needed ground cover to help maintain watershed values. Recreational bird watching, dispersed and developed area recreation, and hunting are also other uses for this grassland, which has become a focal point for issues such as wildlife habitat, riparian area management, and livestock management activities.

The Curlew Valley has been identified as an important bird area in the state of Idaho. Wildlife habitat for Sharp-tailed grouse, sage grouse, and other sagebrush associated species are important management considerations.

Introduction to Methods

Vegetation maps depicting existing vegetation types, canopy cover and tree size class were developed using moderate and high resolution imagery, topographic data, ancillary GIS layers, field and photo-interpreted reference data, automated image segmentation, and data mining classification techniques.

The remotely sensed imagery assembled for this project included both satellite and aerial imagery. Twenty-two Landsat scenes (30-m. spatial resolution) were mosaicked to form three seasonal mosaics depicting spring, summer, and fall conditions. Aerial imagery included 2009 National Agricultural Inventory Program (NAIP) and 2011 resource photography, at one meter and 0.5 meter resolutions, respectively. Topographic information was derived from ten-meter digital elevation models (DEM). Other ancillary GIS layers that were gathered include climate, geology, wildfire severity layers, and IfSAR data.

Clouds were removed from the Landsat imagery and high resolution NAIP imagery was mosaicked and resampled to ten meters. All imagery and topographic derived information were projected to a common coordinate system (UTM, NAD83, and zone 11 N.). Modeling units (image segments) were developed using the resampled NAIP imagery, topographic data, and Landsat derived indices[1]. Reference sites for field data collection were placed in homogenous modeling units accessible by roads or trails. Field crews visited these sites during the summer of 2011 and recorded information on species composition, canopy cover, and tree size class. Additional reference information was also obtained from previously collected plot data, and supplemented using additional photo-interpretation methods.

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[1] See Appendix I.

Map unit labels (vegetation type, canopy cover, and size class) were assigned to modeling units using Random Forests (Breiman 2001). Random Forests is a method of automated computer classification and regression that uses reference and geospatial data to develop decision trees. Each vegetation map (vegetation type, canopy cover, and size class) was developed separately using distinct reference data sets and geospatial data layers. Draft maps, both digital and hard copy, were distributed to local resource specialists for comment and review. Revisions were made to the maps, including manual edits and adjustments to the classification models.

Maps were finalized by aggregating and filtering the modeling units to the minimum map feature size. Riparian vegetation types were filtered to a two-acre minimum, while all other vegetation types were filtered to five acres. Final maps were edge-merged with the 2007 Bridger-Teton mid- level existing vegetation map. An accuracy assessment was conducted and descriptions of the vegetation type map units were written.

Results Summary

The final map products depict continuous land cover information for the entire project area including the Caribou-Targhee NF, private land inholdings, and state land inholdings. Maps are formatted as a geodatabase, which is compatible with Forest Service corporate GIS software. The vegetation maps are consistent with mid-level mapping standards set forth in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2014 in press). In conformance with these standards, modeling units were aggregated up to five acres, with the exception of riparian, agriculture, water and urban areas which were aggregated to two acres.

Additional products include field-collected reference information and photographs, seasonal Landsat image mosaics and derived vegetation indices, topographic derivatives, climate data, canopy surface information derived from IfSAR (radar), and burn severity information for the years 1984 to 2010.

The following products and associated data were assembled or generated for this project:

- Existing vegetation type map
- Tree and shrub canopy cover class map
- Tree size class map
- Field-collected reference data and ground photographs
- Three seasonal Landsat Thematic Mapper mosaics and associated vegetation indices
- Digital elevation models & topographic derivatives

IfSAR surface model
MTBS burn severity
Climate data

Partnerships

The mid-level existing vegetation products were collaboratively planned, developed, and implemented by technicians and experts within the Forest Service. These partnerships were critical to ensuring the highest level of integrity, objectivity, and usefulness for internal uses such as landscape assessments, and for external consumption by the public. The primary participants in the development include Forest and Regional staffs, the Remote Sensing Applications Center (RSAC) and the Interior West Forest Inventory and Analysis (IWFIA) Program of the Rocky Mountain Research Station[2].

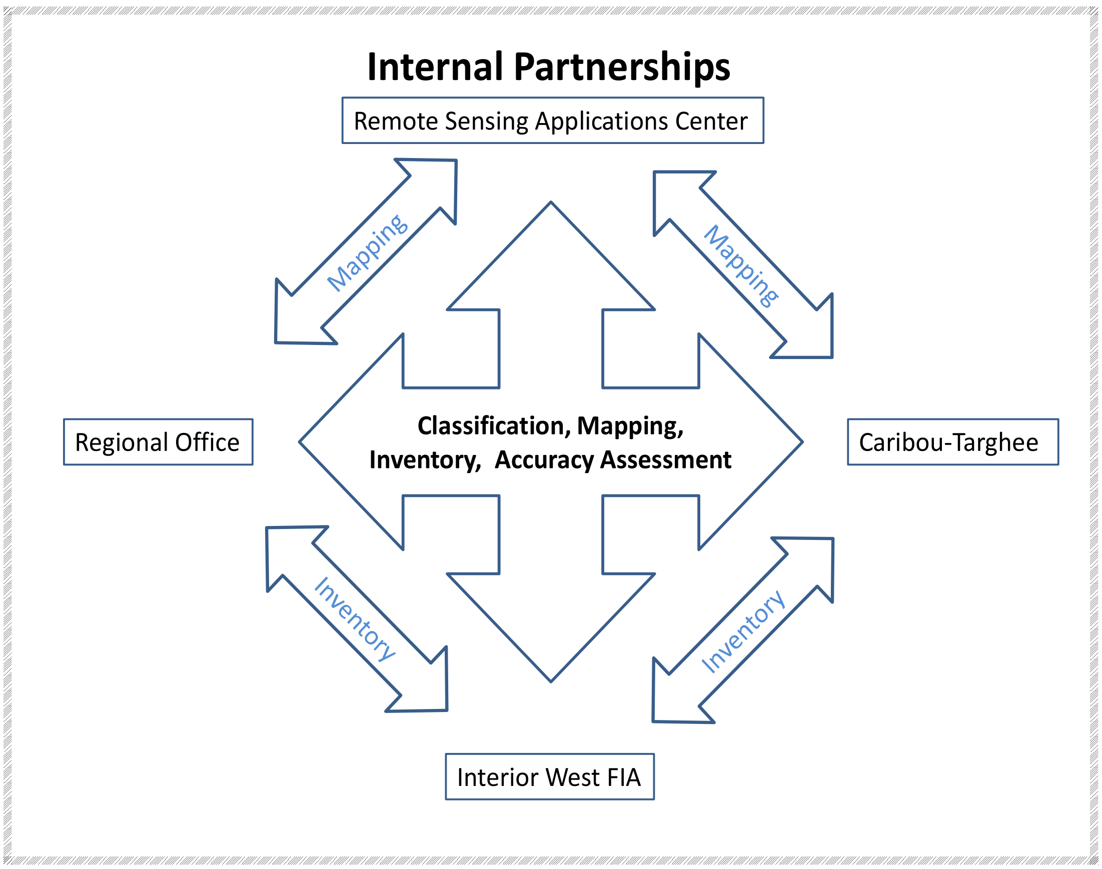

Figure 2: Partnerships developed for the classification, mapping, inventory, and accuracy assessment conducted on the Caribou-Targhee National Forest.

[2] See Appendix II.

The Remote Sensing Applications Center (RSAC) is a national technical service center of the USDA Forest Service. The mission of RSAC is to provide the Forest Service with the knowledge, tools, and technical services required to use remote sensing data to meet the agency's stewardship responsibilities. RSAC's Mapping, Inventory and Monitoring program provides operational remote sensing support and analysis services to help meet internal and interagency programmatic assessment and monitoring needs, such as this existing vegetation mapping project. RSAC is the principal participant in remote sensing technical expertise and map production techniques for this effort, including co-author of this document. The center has assisted this effort in all aspects: remote sensing, image segmentation, image analysis, field reference data protocol and sample design, map filtering, map production, and draft map reviews.

The IWFIA unit operates under technical guidance from the Office of the Deputy Chief for Research and Development, located in Washington, DC, and under administrative guidance from the Director of the Rocky Mountain Research Station located in Fort Collins, Colorado. This research unit provides ongoing support for the inventory aspects of the project: FIA inventory on forest land and All-Condition Inventory (ACI) on nonforest plots, contract inspections, data collections, database assistance, pre-field inspections, intensified inventory sample design, accuracy assessment, and photo interpretations. Their participation ensures consistency and establishes credible and defensive inventory data to be used in conjunction with the derived map products.

The Intermountain Regional Office established the VCMQ core team in 2009 to create existing vegetation products for regional and forest-level uses, such as forest-planning-level analysis, broad-scale analysis, monitoring, assessments, and as a framework for project-level analysis. The team provides expertise in botany and ecology, silviculture and forestry, remote sensing, inventory and mapping, GIS, and program management.

The Caribou-Targhee NF is a primary stake holder in the derived outcomes of this project since they administer the lands and use these products for land management activities. The Forest has collaborated on all aspects of the vegetation mapping project from the initial needs assessment to the final accuracy assessment. A focused group of forest resource specialists, contract specialists, and GIS specialists helped identify tasks and deliverables, made recommendations based on user needs, and served as Forest representatives to the collaborative effort. A broader audience of resource specialists and program managers reviewed draft map products, provided field-based knowledge, and provided input to make the deliverables more meaningful from a Forest perspective. The Forest also accommodated Regional core team needs by providing a botanist to serve short term on the Regional VCMQ team.

Methods

The phases for this project included project planning, vegetation classification development, geospatial data acquisition, image pre-processing, segmentation, field data collection, photo interpretation, modeling, draft map review and revision, and final map development (Figure 3).

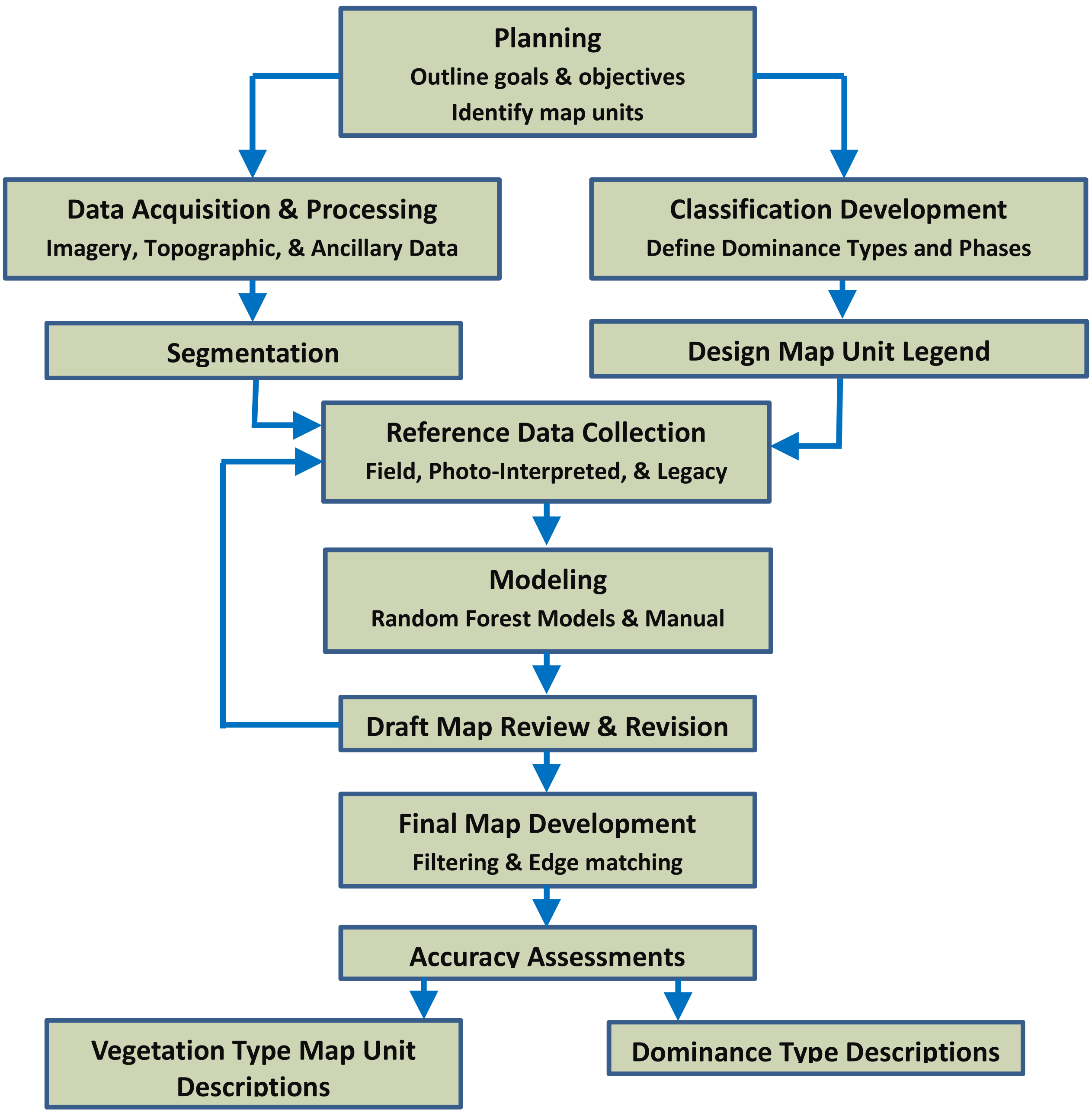

Figure 3: Project phases from project planning to accuracy assessment.

Project Planning

In 2008, staff of the Caribou-Targhee NF, Intermountain Regional Office, and Remote Sensing Applications Center met to discuss map unit design and prepare a project plan. Since one of the goals for the project was to provide a regionally cohesive map product, efforts were made to ensure that spatial and thematic characteristics of the maps as well as processes used would fulfill regional requirements. A classification of dominance types and phases was developed to address forest information needs. These were combined into vegetation types that achieved a balance between map detail and accuracy with the allocated budget and time constraints. The final vegetation type map units conformed to the mid-level mapping standards referenced in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2014 in press), while the, canopy cover, and tree size map units were selected to represent the management needs of the Forest. The study area was divided into five mapping or geographic areas to minimize variation in ecological and vegetation characteristics and ease computer processing constraints (Table 1).

Classification Development

Taxonomic Keys

The Intermountain Region's VCMQ program is designed to classify, map, and quantitatively inventory existing vegetation across the Region. At the regional level, existing plant communities are assigned to dominance types based on the most abundant species of the ecologically dominant life form (e.g., the most abundant tree species in forests or woodlands). This approach was decided upon by a council with representatives from each Forest in the Region.

At the Forest level, the regional dominance types may be subdivided into dominance type phases based on associated species of the same life form as the dominant species. Forests are free to define these phases to best meet their own information needs, as long as they nest within the regional dominance types.

On each Forest, an initial list of dominance types is compiled using vegetation plot data from the Forest and vegetation classification literature relevant to the Forest. The list is reviewed and augmented by Forest resource specialists and local partner organizations. The Forest specialists then determine whether any dominance types need to be split into phases and how those should be defined. Rules for distinguishing phases are tested using the regional plot database and a taxonomic key to dominance types and phases is developed. In practice, phases have only been defined in forests and woodlands, not in shrublands or grasslands.

Once the classification is developed, Forest and Regional specialists develop a map legend by determining which dominance types and phases should be mapped individually, and identifying which dominance types and phases can be combined. Overall map accuracy decreases as the number of map units increases; therefore, the team seeks to balance map detail versus map quality. This process is informed by applying the Forest dominance type key to FIA plot data and estimating the acreage of each type on the Forest. The initial map legend is complete when each dominance type and phase has been assigned to a map unit and included in the dominance type key.

The above process was followed to develop the dominance type classification and map legend for the Caribou-Targhee NF[3].

Plot data used to compile a list of dominance types and test definitions of phases included data collected for classification of conifer forest habitat types (Steele et al. 1983, Mauk and Henderson 1984), aspen community types (Mueggler 1988), and riparian community types (Youngblood et al. 1985, Padgett et al. 1989). Plot data collected for the Targhee TEUI (Bowerman et al. 1997) and the Caribou soil survey update were also used, along with data collected by the Idaho Conservation Data Center in shrublands and riparian communities.

Other relevant vegetation classification literature used in developing the C-T dominance type classification included Bramble-Brodahl 1978, Caicco 1983, Cogan et al. 2005, Collins and Harper 1982, Cooper et al. 1997 and 1999, Cooper and Lesica 1992, Crane and Fischer 1986, Despain 1990, Garrison 2006, Gregory 1983, Hironaka et al. 1983, Mueggler and Stewart 1980, Richardson and Henderson 1999, Rust 1999, Rust and Miller 2008, Sabinske and Knight 1978, Schlatterer 1972, Shiflet 1994, Steele et al. 1981, Svalberg et al. 1997, Tart 1996, Thilenius and Smith 1985, Tisdale 1986, Tisdale and Hironaka 1981, Tisdale et al. 1965 and 1969, Tuhy 1981, Tuhy and Jensen 1982, Urbanczyk and Henderson 1994, Winward 1970 and 1998, and Youngblood et al. 1985.

Structural Characteristics

Structural technical groups for tree size and tree and shrub canopy cover were identified by Caribou-Targhee NF resource specialists to meet business information requirements

[3] See Appendix III.

specified in the land and resource management plans (Forest Plans). Tree size and canopy cover technical groups were established to represent a diversity of vegetation structure and density classes appropriate for informing the management and maintenance of physical and biological processes. The identified classes facilitate the assessment and monitoring of forest and nonforest (rangeland) vegetation, ecological patterns and processes, and wildlife habitat for the management of indicator species such as the northern goshawk and sage grouse. In identifying structure and density map classes, considerations were also made related to the feasibility of mapping the identified categories using mid-level remote sensing mapping techniques.

Tree Size Class

Tree size class or tree diameter class is any interval into which a range of tree diameters may be divided for classification (Helms 1998). Tree size is represented by the plurality of a given class forming the uppermost canopy layer as viewed from above. Indicated in Table 3 and Table 4, tree size classes for timberlands and woodlands do not differ in individual diameter class breaks, but rather in the representation of methods used for measurement. Timberland species are measured using diameter at breast height (DBH) (4.5 feet above the ground), whereas designated woodland species listed in

Table 5 are measured using diameter at root collar (DRC). Specific procedures used for measuring DRC are found in the field reference training data collection protocols.

Table 3: Forest tree size map classes represented by diameter at breast height (DBH).

Forest Tree Size Class	Code
0 – 6.9” DBH	F-TS1
7 – 15.9” DBH	F-TS2
≥ 16” DBH	F-TS3

Table 4: Woodland tree size map classes represented by diameter at root collar (DRC).

Woodland Tree Size Class	Code
0 – 6.9” DRC	W-TS1
7 – 15.9” DRC	W-TS2
≥ 16” DRC	W-TS3

Table 5: Designated woodland species measured by diameter at root collar (DRC).

Symbol	Scientific Name	Common Name
JUOS	*Juniperus osteosperma*	Utah juniper
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper
ACGR3	*Acer grandidentatum*	bigtooth maple
CELE3	*Cercocarpus ledifolius*	curlleaf mountain mahogany

Tree and Shrub Canopy Cover Class

Canopy cover from above represents the total non-overlapping canopy in a delineated area as viewed from above (Nelson et al. 2014 in press). Overlapping canopy not visible from above is not assessed or counted. Canopy cover map classes representing total cover for tree and for shrub are listed in Table 6 and Table 7.

Table 6: Map classes for total tree canopy cover as viewed from above.

Tree Canopy Cover Class	Code
10 - 29%	TC1
30 - 49%	TC2
50 - 59%	TC3
60 - 69%	TC4
≥ 70%	TC5

Table 7: Map classes for total shrub canopy cover as viewed from above.

Shrub Canopy Cover Class	Code
10 - 14%	SC1
15 - 24%	SC2
25 - 49%	SC3
≥ 50%	SC4

Data Acquisition

Geospatial Data

Geospatial data acquisition is a major activity in most vegetation mapping efforts that use digital image processing methods. This project involved assembling remotely sensed images of various spatial and spectral resolutions and an array of geospatial data. A requirement of the mapping process was that any data layer used must be available across the entire Caribou-Targhee NF to ensure consistency. Data used included imagery from the National Agriculture Imagery Program (NAIP), high resolution digital resource photography, topographic data in the form of Digital Elevation Models (DEMs), burn severity information from the Monitoring Trends in Burn Severity (MTBS) program, surface climate conditions data generated by the Daily Surface Weather and Climatological summaries (Daymet), Interferometric synthetic aperture radar (IfSAR) data, and 22 orthorectified Landsat 5 Thematic Mapper satellite images from the years 2006 through 2011[4]. In addition, enterprise data such as the USFS administrative boundary, land ownership, roads, trails, hydrology, harvest activities, ecological type (EUI), and soils resource inventory data were provided by the Caribou-Targhee NF.

Vegetation Plot Data and Photo Interpretation

Vegetation plot data were assembled and acquired, and aerial photo interpretation was conducted to obtain a reference data set representative of the map units (vegetation type, canopy cover, and size class) depicted on the final maps. Reference data are intended to represent a statistically robust sample of broader vegetation conditions across the entire study area. As such, they are used both as training data in model development and to assist with image interpretation. For this project, three types of reference data were used: legacy vegetation plot data, newly collected field data, and photo-interpreted information.

Legacy Vegetation Plot Data

Pre-existing plot data from several sources was compiled to develop a list of dominance types on the Caribou-Targhee NF and test criteria for phases. Older data sets could not be

[4] See Appendix IV.

used as reference data for mapping because they were not current and lacked precise geographic locations. Some plots with precise locations were not used for mapping because they could not be related to a specific segment for the modeling process. Table 8 provides a list of data sources and the number of plots used for developing the dominance type classification, and as reference data for vegetation mapping.

Table 8: List of plots used for developing dominance type classifications and reference data for vegetation mapping on the Caribou-Targhee National Forest.

Data Set	Dominance Type Classification Plots	Map Reference Plots
Habitat Type Plots		
Steele et al. 1983	274	---
Mauk and Henderson 1984	6	---
Community Type Plots		
Youngblood et al. 1985	217	---
Mueggler 1988	339	---
Padgett et al. 1989	66	---
TEUI/Soil Survey Plots		
Targhee TEUI	990	929
Caribou Soil Survey Update	734	573
Idaho CDC Plots		
Upland	64	64
Riparian	60	52
Totals	2750	1618

In addition to the above plots, 433 FIA plot/conditions were available from both annual and periodic datasets. These were used in developing the dominance type and the map legend, but were not used as reference data for the mapping process. They were used to assess the overall accuracy of the map and to describe the composition of the final vegetation type map units.

New Field Reference Data

New field reference data were collected in 2011 to capture the variation of vegetation composition communities and structure classes across the project area. Data were collected at pre-selected and field-selected plot locations as well as broader field-selected observation polygon areas. Information gathered included dominant plant species composition, tree and shrub canopy cover, and timber and woodland tree diameter.

Dominance type and corresponding vegetation type map unit were determined according to the existing vegetation keys[5]. Percent canopy cover and associated map unit were identified using ocular estimation and line intercept methods. The collection of field data was conducted under a task order contract established and administered by the Region Office for the purpose of vegetation inventory and reference data collection. The Caribou-Targhee NF performed local task order oversight and conducted field and office data inspections in accordance with the contract quality assurance surveillance plan and established tolerances. Approximately 10% of the field plots were inspected to evaluate field measurements, field classifications, and coding of data sheets and electronic data for final acceptance.

Photo Interpretation

In addition to the field-collected data, aerial photo interpretation was conducted for discernible vegetation composition and structure characteristics to validate and supplement the training reference data set. Supplemental photo interpretation reference sites were acquired for identifiable vegetation types that were not adequately represented in the legacy or newly acquired field sample data sets. All of the new field reference data acquired in 2011 were photo-interpreted to validate segment homogeneity and representativeness of the field calls for vegetation type and structure classes. In addition, for field-visited plots, tree canopy cover as viewed from above was estimated across the full extent of the segment for attaining an interpreted cover class assignment representative of the segment modeling unit.

Image and Geospatial Data Processing

Project Area Buffer

For modeling purposes only, the forest administrative boundary was buffered by 0.25 mile to account for edge effects that can occur along the clipped edge of some topographic and

[5] See Appendix III.

image data sources that may negatively impact the classification models. The buffered area was not included in the final map deliverables. Non-USFS lands (private, state and other) completely contained within Caribou-Targhee NF were included in the project area to maintain spatial contiguity and are part of the final map deliverables. However, no reference data was gathered within these areas or lands within the 0.25 mile administrative boundary buffer.

Temporal LANDSAT

All Landsat imagery was co-registered and obstructions such as haze, clouds, and cloud shadows were removed and replaced to develop three seamless seasonal mosaics: spring, summer, and fall. A regression technique was used to replace clouds and cloud shadows and create seamless mosaics between neighboring Landsat scenes. Model II regression is a statistical technique that uses a common area between two images (i.e., overlap between adjacent Landsat scenes) to develop a regression model for each of the spectral bands on the image. The regression equation is then used to "fit" the target image to the reference image, adjusting the pixel values in the non-overlap areas to facilitate the creation of a seamless mosaic between images. Three spectral indices were produced from the final Landsat mosaics: Normalized Difference Vegetation Index (NDVI), Tasseled Cap, and Principle Component Analysis (PCA). Such indices are useful in discriminating between vegetated and non-vegetated as well as between vegetation cover-types.

Ancillary Geospatial Data

Digital Elevation Models (DEMs) and Topographic Derivatives

Topographic derivatives, including slope, aspect, curvature, heat load, fully illuminated hillshade, and valley bottom were developed from the 10-meter DEM (Ruefenacht 2014). Such topographic models are used in the modeling process to depict environmental parameters that help predict vegetation cover types.

NAIP / High Resolution Imagery

The one-meter NAIP and 0.5-meter resource photography were resampled to ten meters and mosaicked. A python script was developed that extracts the imagery stored on servers at RSAC, resamples the imagery to ten meters, and creates a mosaic for the area of interest. This step increases the processing efficiency of image segmentation by reducing the resulting segment file size while still maintaining image resolution appropriate for mid-level mapping. A Normalized Difference Vegetation Index (NDVI) was produced from the NAIP imagery since the imagery contains both visible and near infrared bands.

IfSAR

Interferometric synthetic aperture radar (IfSAR) data estimates vegetation height by taking the difference between two radar returns with different wavelengths. One wavelength returns to the sensor after contact with the ground and the other wavelength returns to the sensor after coming in contact with vegetation. IfSAR difference products were used for the mapping of tree size class, since it correlates with tree height. Unfortunately, IfSAR data is inconsistent across mountainous terrain where steep slopes prevent the radar data from being acquired and height is modeled in these areas.

Other

In addition to the image and topographic layers, a vegetation change tracker (VCT) layer was developed using the Landsat data record. This layer identified past disturbances using Landsat imagery and automated change detection algorithms (Huang et al. 2010). For this project, VCT was generated for the years 1984 through 2010. Disturbance year was assigned on a pixel basis (30 meter resolution). Pixels with no change were also identified.

All geospatial data, including the ancillary GIS layers, remotely sensed images, and topographic layers, were projected to the UTM Zone 12, GRS 1980, NAD83 coordinate system and clipped to the project area (0.25 mile buffered forest administrative boundary).

Segmentation

Image segmentation is the process of partitioning digital imagery into spatially cohesive polygonal segments or modeling units that generally represent discrete areas or objects on a landscape (Ryherd and Woodcock, 1996). The goal of developing segments is to simplify complex images comprised of millions of pixels into more meaningful and mappable objects. Excluding water bodies, the final modeling units ranged in size from 0.27 to 109 acres with an average size of approximately four acres.

For this project, modeling units were produced using Trimble eCognition's multi-resolution segmentation algorithm (Figure 4). This algorithm is a bottom-up segmentation technique, whereby pixels are recursively merged together based on user-defined heterogeneity thresholds to form discrete image objects. The input data layers used to generate segments were resampled ten-meter NAIP imagery (raw bands and NDVI), Landsat imagery (principal components and Tasseled Cap transformation), and topographic data used as a proxy for riparian zones (fully-illuminated hillshade layer and a valley bottom layer). Modeling units for upland and riparian areas were developed separately to allow for the development of customized parameters for each land type setting.

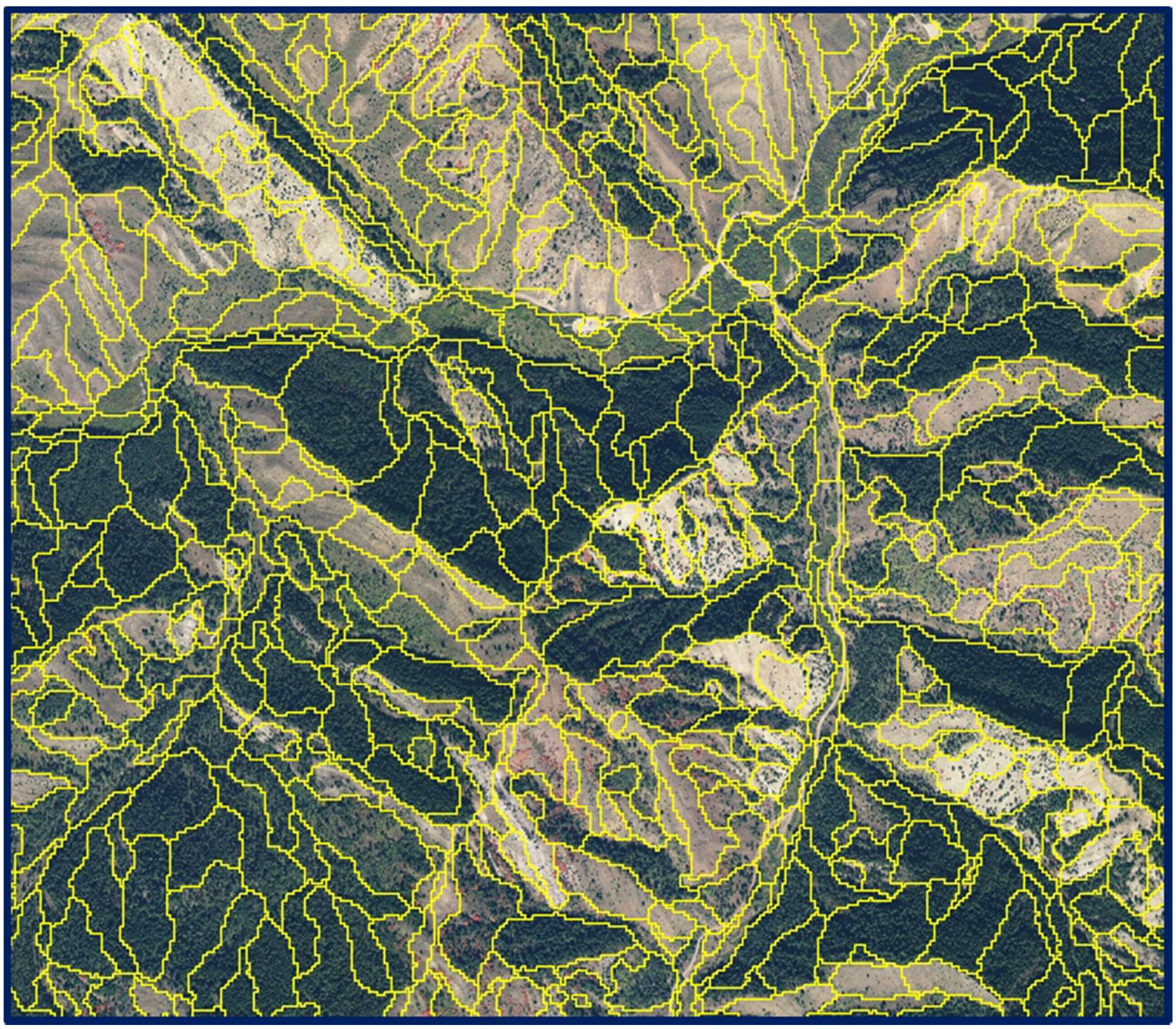

Figure 4: An example of modeling units generated using eCogniton software.

There are four primary parameters within eCognition's multi-resolution segmentation algorithm that control the spatial and spectral quality of the resultant segments. They are: (1) layer weights, (2) scale, (3) shape, and (4) compactness. Layer weights control the relative influence that each of the raster data layers have on the segmentation process[6].

The majority of the influence was given to the spectral NAIP data. While all layers contribute valuable information to the segmentation process, the "texture" of the higher-resolution, multi-spectral NAIP data is often most effective at distinguishing between distinct vegetation types and conditions.

Scale is a unit-less parameter that controls the amount of allowable heterogeneity within segments. Scale parameters can range from 1 to infinity, where the low end would delineate polygons only around identical pixels and the high end would result in the entire study area delineated as a single polygon. As such, scale can also be seen as a proxy control for segment size. A high scale parameter means more heterogeneity is allowed within segments and will ultimately result in larger relative segment sizes. Conversely, a small scale parameter means less heterogeneity is allowed within segments, so smaller segments will result. For the Caribou-Targhee NF segmentation, a scale parameter of 17 was used for upland area and 13 was used for riparian areas. Appropriate scale factors were arrived at by experimentation and previous experience.

The shape parameter controls the type of heterogeneity contained within the resultant segments. It is a relative value that caters to the desire for resultant segments to be controlled by spatial homogeneity (shape) and/or spectral homogeneity (color). The values range from 0.0 (a low shape parameter/high color parameter) to 0.9 (a high shape parameter/low color parameter). Segments created with a low shape parameter will have very spectrally homogeneous segments, but have little regard for the compactness or smoothness of the resultant segment shapes. Conversely, a very high shape parameter will result in segments that have very smooth, compact shapes, but have little regard for the spectral/topographic pixel values. For the Caribou-Targhee NF segmentation, a shape parameter of 0.15 was used for upland areas and 0.2 was used for riparian areas. These values were determined to find a balance between capturing areas of homogeneous land cover, while maintaining spatially functional segment shapes.

Similar to the shape parameter, the compactness parameter actually dictates the balance between two opposing spatial qualities: compactness and smoothness. Compactness can be described as the ratio between the area of a given segment and the area of the smallest

[6] See Appendix V.

bounding box of that segment. A very compact segment (i.e. a circular or square segment) will have a ratio that approaches 1, while a segment with low compactness (i.e. an oblong or linear segment) will have a value that approaches 0. Smoothness can be described as the ratio between the length of a segment's boundary and its area. A very smooth segment will have a short border relative to its area, whereas an irregular segment will have a lengthy border relative to its area. The values of the compactness parameter range from 0.0 (low compactness/high smoothness) to 1.0 (high compactness/low smoothness). For the Caribou-Targhee NF segmentation, a compactness parameter of 0.7 was used for both upland and riparian areas. This value was found to create segments of a desirable spatial quality that best matched the features on the ground.

In addition to the base parameters described above, RSAC has developed additional components to the segmentation rule set, including the definition of a minimum mapping unit (MMU) and associated MMU filtering techniques, and an "object smoothing" process that sends the raw segments through a majority-filter-based re-shaping tool, that results in smoother, more spatially consistent and functional modeling units.

New Field Reference Data Collection & Photo Interpretation

New field reference and photo interpretation data were collected to obtain a training data set containing a sufficient number of samples for modeling vegetation type, tree and shrub canopy cover class, and tree size class. This section describes 1) how the field reference site locations were selected using imagery and topographic GIS layers, 2) methods used for collecting new field data, and 3) the photo interpretation procedures for obtaining supplemental reference sites, tree canopy cover estimates, and the assessment of reference site homogeneity and representativeness.

Pre-stratification and Field Plot Sample Design

Approximately 1,000 reference sites were selected to be visited in the field during the summer of 2011. To maximize site usefulness in classification models, a number of criteria were met. First, sites were located in relatively homogeneous areas as perceived from high resolution aerial imagery so as to provide representative samples of vegetation conditions.

Secondly, sites were large enough (one acre or greater) to capture variation in the geospatial data so as to provide reasonable statistics for a particular sample. Lastly, sites were placed within ¼ mile of a road or trail to facilitate accessibility in the field.

In addition to the criteria above, spectral and topographic stratifications were performed to capture the range of conditions anticipated to occur within each of the geographic areas (GAs). A topographic stratification was generated to identify high and low elevation conditions in each GA. This binary split was determined through an image interpretation-based review of NAIP imagery by locating distinct changes in vegetation communities due to elevation changes. The topographic split was then further stratified using spectral information contained in the 2010 Landsat imagery. An unsupervised classification was performed on the Landsat data for each of the GAs, creating clusters of similar spectral qualities in both high and low elevation areas. Sites were then placed within each of these clusters in varying amounts, depending on the relative size of each GA. A total of 280 field sites were placed in the largest GA 3 (approximately encompassing the Teton Basin, Palisades and portions of the Soda Springs and Ashton/Island Park districts), while only 80 sites were placed within GA5 (Curlew National Grasslands). The distribution of sites by GA is shown in

Table 9.

Table 9: Distribution of field reference sites for each mapping GA on the Caribou-Targhee NF.

GA	# of field sites
1	191
2	178
3	280
4	271
5	80

Field Plot and Observation Polygon Data Collection

New plot data collected in the field consisted of dominance type, vegetation type, percent canopy cover, and tree size using standardized protocols[7]. A 50-foot radius circular plot was established within the segment as identified on a plot map depicting high resolution aerial imagery and image segments. The plot was placed by field crews at a location estimated to be representative of the vegetation community contained within the segment based on a walk-through of the area. The center of the plot and plot boundary in each cardinal direction from plot center was then marked. Because the map represents an overhead view, all vegetation within the plot area was assessed using an aerial perspective from

[7] See Appendix VI.

above the canopy. Overlapping canopy not visible from above was not assessed or counted as part of the estimates.

An ocular estimate of canopy cover for trees, shrubs, herbaceous and non-vegetated cover types was recorded for the plot totaling 100 percent. Canopy cover was estimated for up to the five most abundant species and non-vegetation types having five or more percent cover, and the combined cover of all remaining species and non-vegetation types. In addition to the ocular cover estimates, a transect intercept method was used at regular intervals for shrubland plots to calibrate ocular estimates. Two perpendicular 100-foot transects were run through the plot center. Within each 10-foot transect increment, the number of feet of live canopy cover intercepted for each species was estimated and totaled for each transect. The transect percentages were then averaged to calculate the overall shrub canopy cover for the plot. Based on the plot composition and cover estimates, a dominance type and corresponding vegetation group and vegetation types were assigned to the site using the vegetation keys[8] and map unit cross-walk.

For forest and woodland sites, the percent visible cover from above of each tree size class was ocularly estimated by species and then totaled for each size class. Tree size was determined using DBH for all tree species except designated woodland species consisting of juniper, bigtooth maple and curlleaf mountain mahogany (

Table 5). Tree size for woodland species was determined using DRC. The tree size class having the most abundant total canopy cover was used for assigning the forested plot to a tree size map unit (Table 3 and Table 4).

For forest, woodland, and shrubland sites, total life form canopy cover was estimated to assign the plot to a tree or shrub canopy cover map unit. Upland forest and woodland sites were assigned to a tree canopy cover map unit (Table 6). Riparian shrubland and deciduous forest, and upland and alpine shrubland sites were assigned a shrub canopy cover map unit (Table 7).

For each plot established by field crews, three to four field observation sites were collected to quickly acquire additional vegetation information within the extended vicinity of the field plot. The plot maps depicting high resolution aerial imagery and image segments were used to identify observation polygons (segments) representing homogenous vegetation. Once a segment from the plot map was identified in the field, dominance type, vegetation type and group, canopy cover class, and tree size class were estimated for the segment. A variety of

[8] See Appendix III.

vegetation types and structure classes were targeted to capture the representative vegetation communities occurring within the project area.

Photo Interpretation

Aerial photo interpretation was conducted by Caribou-Targhee NF resource experts and Interior West Forest Inventory and Analysis (IWFIA) field personnel who were familiar with local vegetation characteristics and conditions. An integrated approach combining field experience, field sampled data and aerial photo interpretation was used to characterize vegetation composition and structure from digital high resolution resource aerial imagery[9]. The photo interpretation process provided an efficient and cost-effective means to supplement and validate the field-based data.

Supplemental Sites

Approximately 300 photo-interpreted reference sites were acquired in areas that were remote or inaccessible by field crews to provide supplemental site data for vegetation types lacking an adequate number of field samples. Forest resource specialists provided input on known general locations of vegetation types targeted for photo interpretation. In addition, reference data collected by crews in the field during the previous field season were used to familiarize interpreters with image characteristics of known vegetation types in order to calibrate estimates and guide photo interpretation. Additional vegetation types acquired through photo interpretation included, but were not limited to whitebark pine, mountain mahogany, and riparian.

Tree Canopy Cover Estimates

To ensure consistent tree canopy cover estimates, all forested field site canopy cover calls were reassessed by photo interpretation. Tree canopy cover as viewed from above was estimated across the full extent of each segment. Canopy cover was interpreted by comparing cover within the segment to known canopy coverage scales and interpreted examples. In addition, a digital layer containing polygons representing ten percent of the area of each segment was overlaid to aid in determining whether the site met the minimum

[9] See Appendix VII.

ten percent tree canopy cover required to be classified as forest and to estimate cover in ten percent increments.

Homogeneity and Representativeness

Photo interpretation was also used to assess segment homogeneity and representativeness of the field training reference sites. Homogeneity interpretations involved identifying whether each segment containing a field reference site represented a homogenous vegetation formation. The representativeness of the field training reference site was determined by identifying whether the field-assigned attribute for vegetation group, vegetation type, and tree size class (as applicable) reasonably represented the majority of the segment. Together with the photo interpretation for homogeneity of the segment, the representativeness interpretation allowed for assessing the suitability of each field site attribute for appropriate use as training reference data in the modeling process.

Modeling

Modeling refers to the step in the mapping process that develops the relationships between the reference data and the geospatial data and applies those relationships to build a map. Modeling is an iterative process starting with separating the most distinct classes (e.g. sparse vegetation/alpine versus vegetated at level 1) and progressing to those that are more difficult to separate (e.g. different types of sagebrush). During this iterative process, a mapping hierarchy is developed to better understand how the vegetation characteristics will separate based on the geospatial data being used in the modeling process. This mapping hierarchy determines the sequence in which the models will be run and which classes will be most difficult to separate. For example, in Figure 5 the first level of the hierarchy shows that sparse vegetation/alpine (SV_ALP) can easily be separated from the rest of the vegetation (VEG). Level two shows how the model then separates vegetation into three classes: Conifer (Con_1), mesic, and xeric and so on down through the levels. Each applied model along the way has an associated accuracy for that particular run determined by holding back a random subset of reference data and using it to assess the results of the model. A different set of reference data is selected to develop each of the three map layers (vegetation type, canopy cover and tree size) based on how well the reference sites predict the characteristics of each map. While many of the same reference sites are used in all of the models, some are used in only one or two of the map layers. The modeling for each of the map layers is described below.

An important step in the modeling process was the development of draft maps to share with resource specialists. This step allowed resources specialists to take maps into the field and/or compare to other sources, including local knowledge. The feedback provided during this process allowed the mappers to make changes and improvements prior to final map delivery.

Map Types

Vegetation type map

Vegetation types were mapped for each GA using a hierarchical approach (Figure 5). Broad life form types, such as conifer and non-conifer, were mapped first. These communities were subsequently divided into more distinct communities until the final vegetation types were mapped. There are several advantages to using this hierarchical approach. First and foremost, it enabled a targeted review of each level map, where obvious errors were addressed at the upper levels of the hierarchy and not carried through to the rest of the classification.

The mapping hierarchy was developed using a data clustering technique based on the relative separability of each vegetation type. Separability was determined by how well the spectral and ancillary data could distinguish between vegetation types. It is quantified by a value known as "entropy" which measures how well a model could be expected to separate vegetation types beyond random chance. Vegetation types with low entropy values are expected to be modeled poorly and vegetation types with high entropy values are expected to be modeled well. The mapping hierarchy was built from the bottom up, by identifying and aggregating the least separable classes first.

For each level of the mapping hierarchy, a Random Forests model (Breiman 2001) was developed, and the resulting output map was carefully evaluated. To correct problems, reference data were reevaluated, changes or additions were made, and an updated model was developed. This modeling procedure was repeated until the maps were considered satisfactory.

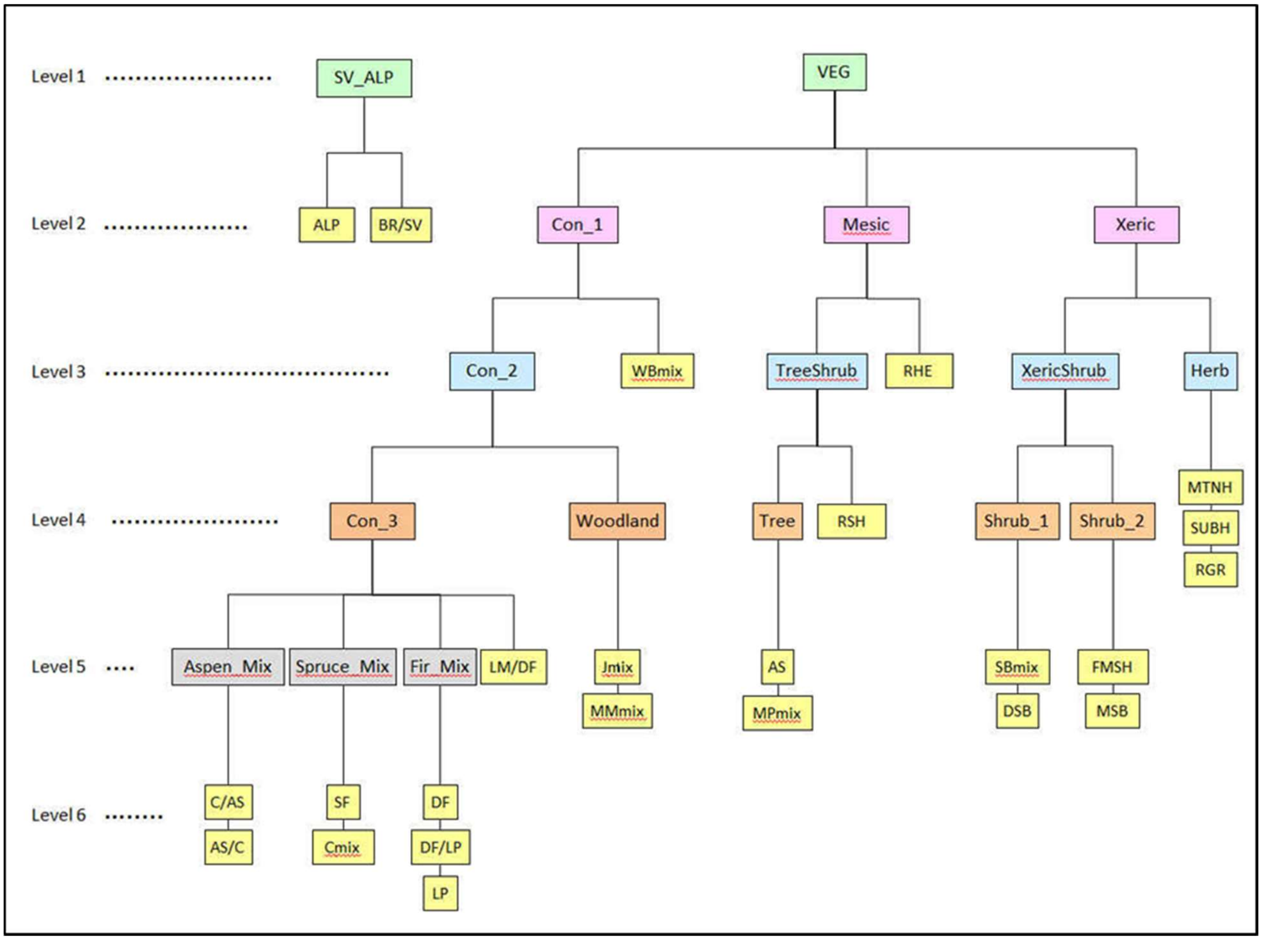

Figure 5: Mapping hierarchy example used in the modeling process for the vegetation type map. Successive models were developed starting with level 1 (broad separation of land cover) and progressing to higher levels (more refined). At each level a separate map was developed and reviewed for accuracy.

There were several wildfires in the project area encompassing approximately 121, 000 acres. Monitoring Trends in Burn Severity (MTBS) data from 2000 to 2010 were used to identify areas of high and moderate burn severity. Because of spectral differences that occur between burned and unburned areas with the same vegetation type label, reference sites that intersected with burn areas were reviewed to determine if they were appropriate for use in developing the classification models (Figure 6). Most of the sites identified as burned occurred in the Curlew National Grasslands. These areas were modeled separately from the unburned regions to mitigate mapping errors. In other mapping GA's, manual edits and photo-interpretation were used to label the burn polygons.

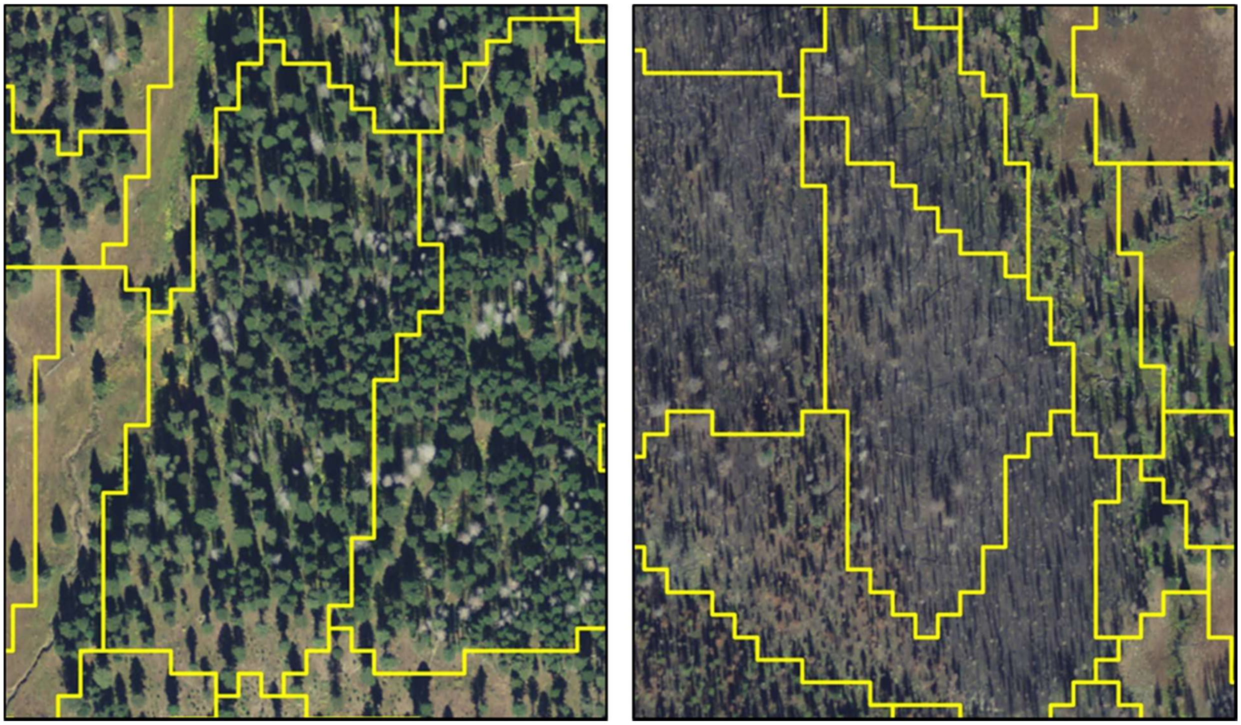

Figure 6: The image on the left shows an unburned Douglas-fir stand, while the image on the right shows a burned forest with enough live trees to be labeled a Douglas-fir stand.

Forest and shrubland polygons were identified and the canopy and forest size class maps were developed for these areas. These maps were produced using the same modeling procedures as previously described however, no map hierarchy was used. Separate models were developed for tree canopy, shrubland canopy, tree size class, and woodland size class modeling units.

Canopy Cover Class Map

Canopy cover class was assigned to modeling units identified on the vegetation type map as forest, woodland, or shrubland. The canopy cover for forest and woodland sites were photo-interpreted, while shrubland sites were assessed and revised by the regional ecologist.

To optimize modeling effectiveness, vegetation types were sorted into seven canopy groups based on vegetation similarities (Table 10). Some groups contained multiple vegetation types while others contained a single type. A Landsat 5 Thematic Mapper summer mosaic was used to develop an unsupervised classification to produce unique clusters of pixels with similar values. A canopy cover class was assigned to each cluster by analyzing how the reference data for canopy cover intersected with each unsupervised cluster. By comparing the canopy cover classes in the reference data to the clusters, each cluster was assigned a canopy cover class. Some clusters contained reference sites with multiple canopy cover classes. In these scenarios, the cluster was assigned the canopy cover class that maximized the agreement with the reference data.

Following the assignment of a canopy cover class to each pixel; it was necessary to assign a canopy cover class to each segment. This was done by calculating the majority canopy cover class pixel value contained in each segment. Since this was done for each cover type group separately, it was necessary to mosaic the eight canopy cover maps into one wall-to-wall map of the Caribou-Targhee NF.

Table 10: Canopy cover groups used for modeling canopy cover.

Canopy Cover Groups	Vegetation Type
Aspen	Aspen
Aspen Mix	Aspen/Conifer and Conifer/Aspen
Conifer	Douglas-fir, Douglas-fir/Lodgepole Pine, Limber Pine/Douglas-fir, Lodgepole Pine, Spruce/Fir, Conifer Mix, and Whitebark Pine Mix
Maple	Bigtooth Maple Mix
Woodlands	Juniper Mix and Mountain Mahogany Mix
Mesic Shrublands	Forest/Mountain Shrublands
Sagebrush	Dwarf Sagebrush, Mountain Big Sagebrush, and Dry Big Sagebrush Mix
Riparian	Riparian Shrubland and Deciduous Forest

Tree Size Class Map

Tree size class was assigned to modeling units identified as a forest or woodland on the vegetation type map. A total of 645 reference sites were used in developing the tree size class models. These sites were visited on the ground by field crews, and reexamined in the office for consistency and accuracy.

To optimize the modeling, forest and woodland vegetation types were sorted into seven groups based on the distribution of the training data (Table 11). Conifer types were divided into two groups to separate those types associated with the larger tree size class from those that rarely exhibit large tree diameters. Vegetation types with disparate spectral characteristics (e.g. classes containing aspen) were isolated to limit confusion in the modeling process. Each of the woodland vegetation types were also modeled independently, because diameter was measured at the root collar instead of at breast height, and because of their unique spectral characteristics.

Table 11: Tree groups and the associated vegetation types used for tree size mapping.

Tree Groups	Vegetation Type
Group 1 Aspen	Aspen
Group 2 Aspen Conifer Mix	Aspen/Conifer and Conifer/Aspen
Group 3 Conifer 1	Limber Pine/Douglas-fir, Lodgepole Pine, and Whitebark Mix
Group 4 Conifer 2	Douglas-fir, Spruce/Fir, and Conifer Mix
Group 5 Bigtooth Maple Mix	Bigtooth Maple Mix
Group 6 Juniper Mix	Juniper Mix
Group 7 Mountain Mahogany Mix	Mountain Mahogany Mix

Tree size was modeled independently as a continuous response variable for each tree group. There were seven data sources and a total of 24 metrics used as predictors[10]. The Vegetation Change Tracker (VCT) data layer used in this process helped to detect disturbances and highlight forest change. This layer was especially useful in identifying regions affected by fire or harvest activity.

Assembling Draft Maps

The individual GA maps for each map theme (vegetation type, canopy cover, and tree size class) were edge-matched to produce continuous maps for the entire project area. Edge-

[10] See Appendix VIII.

matching consisted of delineating a cut-line in the overlap area between adjacent GAs (Figure 7). The cut-line followed natural topographic breaks such as ridgelines and stream channels, so as to not split areas of continuous vegetation types.

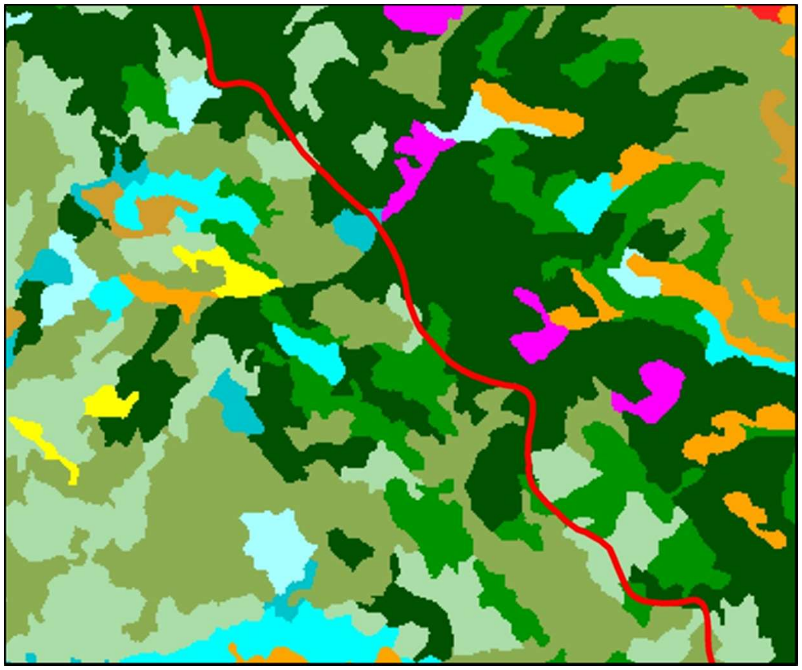

Figure 7: The cut line (shown in red) between GA3 and GA4.

Draft Map Review and Revision

The vegetation type draft map was provided to local resource specialists for comment and review. Meetings were held in Soda Springs and Ashton, Idaho, where the review process and associated review materials were presented to the Caribou-Targhee NF staff, using both digital Webmap services, and hardcopy map products. This was an opportunity for local experts[11] to assess the map and provide additional information to make improvements[12].

All the draft map review comments were compiled and reviewed by the vegetation mapping team, and the recommended changes were used to produce the final vegetation type map.

[11] See Appendix II.
[12] See Appendix IX.

Final Map Development

For the vegetation type map, adjacent polygons having the same labels were combined. To achieve a minimum map feature size of two-acres for riparian, water, agriculture, and developed areas and five acres for all other vegetation types, map features below these thresholds were merged based on a set of rules developed by the Regional Office and Caribou-Targhee NF staff[13]. The rules followed logic based on similarities between adjacent polygons so that neighbors were merged with the most similar type of vegetation. An example of this process referred to as dissolving and filtering, is shown in Figure 8.

For the canopy cover and tree size maps, map features were also dissolved and merged using the same process described above. For example when filtering a TS1 map feature, the first neighboring map feature that it attempts to merge with is TS2 (most similar).

The final vegetation type, tree and shrub canopy cover, and tree size class maps were edge-merged with the 2007 Bridger-Teton mid-level existing vegetation maps. Because of boundary issues, including overlaps and gaps, some Bridger-Teton classes were introduced into the Caribou-Targhee NF map. These classes are clearly identified in the legend and account for approximately 2,500 acres (0.1 percent of the area).

[13] See Appendix X.

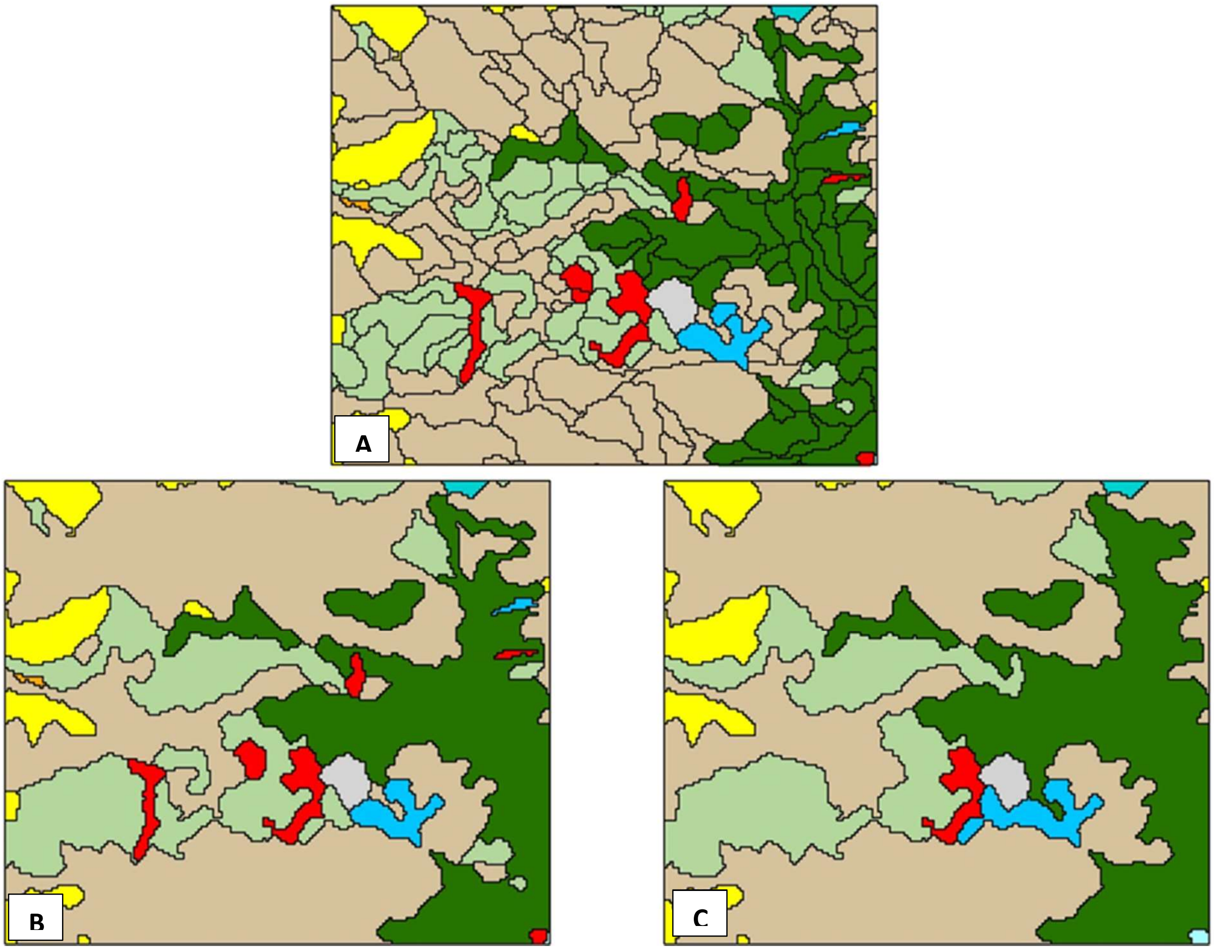

Figure 8: An example of the dissolving/merging and filtering process that was performed on the final maps. Image A shows the original vegetation type map with no dissolving or filtering. Image B illustrates the dissolving and merging of adjacent map features labeled with the same vegetation type. Image C illustrates the filtering process. Upland areas (green, yellow, grey and blue) less than five acres were merged with similar adjacent map features based on the filtering rule-set.

Map Products

The final map product delineates the geographic distribution, extent, and landscape patterns of vegetation types and structural characteristics for the Caribou-Targhee NF and approximately 40,000 acres of lands not owned by the Forest Service. The maps are formatted as a digital geodatabase and raster data layers, compatible with USDA Forest Service corporate GIS software. All data is projected into the Universal Transverse Mercator (UTM) coordinate system, North American Datum (NAD) 83, Geodetic Reference System (GRS) 1980, zone 12. The three maps depict Vegetation Type (VT), Canopy Cover (CC), and Tree Size Class (TS). Some map units from the Bridger-Teton mid-level existing vegetation maps are included on the Caribou-Targhee NF maps, along the coincident border between the two Forests. The minimum map features size was two-acres for riparian, agriculture, water, and developed areas and five acres for all other vegetation types.

Vegetation Type and Group

A total of 27 vegetation types were mapped. These vegetation types and associated acres and percentages are shown in Table 12. Classes ranged from individual vegetation species (e.g., Douglas-fir) and vegetation communities (e.g., ruderal grassland) to more general ones such as agriculture.

Table 12: Total acres and areal percentage for each vegetation type within the Caribou-Targhee National Forest administrative boundary (Administrative boundary from Caribou-Targhee National Forest).

Forest/nonforest Vegetation Group	Vegetation Type	Area	Percent area
Forest and Woodland	Douglas-fir	574,911	19.9%
	Lodgepole Pine	460,550	15.9%
	Conifer Mix	218,531	7.5%
	Aspen	218,152	7.5%
	Spruce/Fir	122,706	4.2%
	Conifer/Aspen	115,549	4.0%
	Bigtooth Maple mix	86,905	3.0%
	Aspen/Conifer	83,726	2.9%
	Mountain Mahagony Mix	60,477	2.1%
	Douglas-fir/Lodgepole Pine	55,519	1.9%
	Limber Pine/Douglas-fir	51,877	1.8%
	Whitebark Pine mix	29,041	1.0%
	Juniper mix	27,147	0.9%
Forest and Woodland Total		**2,105,091**	**72.7%**
Nonforest	Mountain Big Sagebrush	422,008	14.6%
	Forest/Mountain Shrublands	77,031	2.7%
	Barren/Sparse Vegetation	51,432	1.8%
	Subalpine Herbaceous	44,572	1.5%
	Montane Herbaceous	34,622	1.2%
	Dwarf Sagebrush	33,623	1.2%
	Dry Big Sagebrush Mix	31,414	1.1%
	Riparian Shrublands/Deciduous Tree	26,027	0.9%
	Alpine Vegetaton	25,898	0.9%
	Ruderal Grasslands	19,522	0.7%
	Water	17,768	0.6%
	Riparian Herbaceous	3,991	0.1%
	Developed	2,542	0.1%
	Agriculture	659	0.0%
Nonforest Total		**791,108**	**27.3%**
Grand Total		**2,896,199**	**100.0%**

Tree and Shrub Canopy Cover

The tree and shrub canopy cover map was developed independently for tree canopy cover (areas mapped as forest or woodland) and shrub canopy cover (areas mapped as shrubland) (

Table 13). All other vegetation types were not assigned a canopy cover class.

Table 13: Total acres and percentage for each tree and shrub canopy cover class. Non-National Forest System lands were not included in the acres calculations.

	Values	
Tree canopy class	**Area**	**Percent area**
TC1 (10-29%)	755,049	35.9%
TC2 (30-49%)	667,124	31.7%
TC3 (50-59%)	362,348	17.2%
TC4 (60-69%)	205,276	9.8%
TC5 (70%+)	115,294	5.5%
Grand Total	**2,105,091**	**100.0%**

	Values	
Shrub canopy class	**Area**	**Percent area**
SC3 (25-49%)	293,405	49.7%
SC2 (15-24%)	118,245	20.0%
SC1 (10-14%)	99,234	16.8%
SC4 (50 %+)	79,218	13.4%
Grand Total	**590,102**	**100.0%**

Tree Size

A tree size map was developed for all areas identified as forest or woodland in the existing vegetation map. These lands were classified into five tree size classes (Table 14). All other areas were mapped as nonforest. The “BT” tree size that was 0.1% of the project area represents those polygons that were mapped on the boarder of the Bridger-Teton National Forest and represent tree size classes for that forest.

Table 14: Total acres and percentage for each tree size class. Lands not managed by the National Forest System lands were not included in the acres calculations.

Tree-size class	Area	Percent area
F-TS2 (7.0-15.9" DBH)	1,126,501	53.5%
F-TS1 (0-6.9" DBH)	440,773	20.9%
F-TS3 (16.0"+ DBH)	363,289	17.3%
W-TS2 (7.0-15.9" DRC)	93,964	4.5%
W-TS1 (0-6.9" DRC)	66,769	3.2%
W-TS3 (16.0"+ DRC)	13,795	0.7%
Grand Total	**2,105,091**	**100.0%**

Additional Products

The additional products developed as part of the vegetation mapping project include field-collected information, mosaics of standard geospatial data sources, and numerous image indices and topographic derivatives. Table 15 shows a list of additional products.

Table 15: Additional products that were developed and delivered as a result of the mapping project.

Product
Field visited samples & ground photographs
Field observations samples
Photo-interpreted samples
Legacy data
Enhanced image products and topographic data
Multi-temporal Landsat Thematic Mapper imagery and indices (NDVI, Tasseled Cap, and PCA)
Digital Elevation Models and derivatives (slope, aspect, curvature, fully illuminated hillshade, and heat-load)
Interferometric synthetic aperture radar (IfSAR)
MTBS burn severity
Climatic data

Accuracy Assessment

An accuracy assessment for a mapped product can be defined as a statistical summary or metric, usually presented as a table, comparing the mapped classes to reference data or "truth." An accuracy assessment should provide objective information on the quality or reliability of the map, and can be used to determine the utility of the map and the associated risks of the map with respect to specific applications" (Nelson et al., in press). Thus, it is paramount that the reference information used to conduct accuracy assessments be independent from the information used to produce the map, and also be a reliable and unbiased source for representation of ground conditions.

The most current Forest Inventory and Analysis (FIA) base-level, field-collected data available were used for this accuracy assessment. This included a spatially complete systematic hex-grid sample for all forest and nonforest lands on the Caribou-Targhee NF. The source data set for this analysis was approximately eight years (2004-2011) of forest and ten years (2004-2013) of nonforest FIA annual inventory plots in Idaho on the Caribou-Targhee NF. For the Wyoming portion of the Forest, the most current periodic inventory (2002) was used for area estimates along with one subcycle (2011) of annual plot data used to replace a small portion of the older periodic plots.

Systematic inventory plots provide a spatially balanced estimate of map unit (e.g., vegetation type, canopy cover, and tree-size) proportions for a population. As FIA completes its annual inventories for Idaho and Wyoming, more annual data will be available to update the Caribou-Targhee NF base-level accuracy assessments. By 2014 a full cycle (10 years) of forest and nonforest FIA annual data will be available for all Idaho Forests. As the Forest completes its intensified inventories, more data can be leveraged off the base-line for improving the reliability of class accuracies that contain few FIA samples. Thus, it makes sense to start with the FIA base-level assessment and update as more FIA annual and intensified inventory data become available.

Region 4 is currently in the process of standardizing the use of the FIA base-level grid for its mid-level map accuracy assessments on Forests throughout the region. This should also include standardization of supplemental reference datasets (e.g., intensified inventories) at the Forest level. Below are more detailed discussions concerning: 1) the use of reference datasets for accuracy assessments, 2) the use of the map product from the accuracy assessment perspective, and 3) the accuracy assessment design.

Use of Reference Datasets for Accuracy Assessments

Reference data is quantitative or qualitative information about ground features necessary to successfully complete a map accuracy assessment. Although the collection of field reference data is not required, some type of reference data is needed to help interpret and/or assess accuracy during a mapping project. Quantitative accuracy assessments usually depend on the collection of reference data, which is assumed to be known information of high accuracy (Brewer et al. 2005).

There is rarely a sufficient sample size to quantify all vegetation types occurring across a geographic area. Important types of naturally small extent, such as riparian communities, are rarely sampled by a systematic or random design. Inventory data, therefore, involves trade-offs between resolution and reliability. It is often necessary to generalize or aggregate vegetation types and /or structural classes in order to achieve the sample sizes needed to provide statistically reliable estimates of the amounts of those types or classes (Brewer et al. 2005).

When data collection protocols for accuracy assessment samples are similar to those of the training samples, then assigning the appropriate map unit label to an accuracy assessment sample is straightforward. If plot designs are dissimilar, then developing a crosswalk and reinterpreting or verifying plot information using high-resolution imagery, or conducting field visits may be necessary. When existing data, such as FIA data, is used to assess map accuracy, consideration should be given to address differences in data collection methods (Stehman and Czaplewski 1998). The following are some limitations that need to be considered when using FIA data for accuracy assessments:

- Size of FIA plot vs. unit of evaluation for the map
- Nature of FIA condition boundaries vs. mapped polygon boundaries
- Vintage of field collected data of annual cycle versus imagery vintage
- Insufficient numbers of accuracy assessment sites for less common classes

Although the use of FIA data as a reference dataset for accuracy assessments has its limitations, it also has many advantages. FIA data are a statistically robust, spatially distributed, unbiased sample that is updated annually over a 10-year cycle. It has well-established and consistent data collection protocols that facilitate multi-temporal comparability and long-term usage, and is readily available to users.

FIA data can be used early in the classification scoping process to identify or distinguish rare (< 1 percent of Forest), uncommon (one to ten percent), and common (>ten percent) classes. Rare classes are typically too spatially-limited for normal mid-level mapping processes, and may need to be “burned in” later using local Forest knowledge. This process can help make the mapping process more efficient, by reducing the number of initial classes and the number of classes that may need further collapsing after accuracy assessments based on too few samples.

For the less common classes, other sources of reference information are often needed (e.g., intensified, stratified or photo-interpreted data).

Use of Map Products

Map features (e.g., polygons) are rarely pure; instead, they usually contain varying proportions of vegetation, structure, and cover class mixtures. Therefore, map products should be used within the context of the map unit and the associated dominance type descriptions.

The map assessment may identify map units with low accuracy. These map units may meet the desired thematic detail, but not the desired thematic accuracy. By assessing the error structure relative to the mapping objectives and management questions, map units can be combined into new, more generalized map units that better meet accuracy requirements. Merging map units is not an edit or a correction to the final map; rather, this process is a generalization of the map legend to achieve an acceptable compromise between thematic detail and classification accuracy (Nelson et al., in press).

Accuracy Assessment Design

The three basic components of an accuracy assessment are the sample design, the response design, and the analysis protocol (Stehman and Czaplewski 1998). The sample design determines the plot design and the distribution of sites across the landscape; the response design determines how the sites are labeled or assigned to map units; and the analysis protocol summarizes the results of information obtained from the sampling and response designs.

Sample design and sample size (number of samples) are important considerations for an efficient accuracy assessment. The *sample design* should be statistically and scientifically valid. The sampling unit (i.e., polygon or point) should be identified early in the process, since it affects much of the plot design. While training data used for producing a map may be collected according to a preferential or representative sampling scheme (purposive sampling), data used for accuracy assessment should be collected using an unbiased approach, where samples have a known probability of selection (Stehman and Czaplewski 1998). The number of sample sites should be large enough to be statistically sound but not larger than necessary for the sake of efficiency. The need for statistical validity is often balanced with practical considerations, such as time and budget constraints (Nelson et al., in press).

The *response design* includes procedures for collecting the accuracy assessment samples, and protocols for assigning a map unit label to each accuracy assessment sample (Stehman and Czaplewski 1998). If an existing data set is used, determine whether the existing information is sufficient for assigning a map unit label, or if additional information or interpretations are needed.

The *analysis protocol* summarizes the results of information obtained from the sampling and response designs (Stehman and Czaplewski 1998). A primary objective of an accuracy assessment is to quantify the level of agreement between mapped and observed attributes. This is most often performed for classified (categorical) maps by creating an error matrix, and deriving the accuracies from that matrix. The error matrix is the standard way of presenting results of an accuracy assessment (Story and Congalton 1986). This matrix is a cross-tabulation table (array) that shows the number of reference sites found in every combination of reference data category and map unit category. Agreement can also be measured by comparing the similarity of the mapped and observed proportions of the attributes within the mapped area.

Quantitative Inventory

Quantitative vegetation inventory consists of applying an objective set of sampling methods to quantify the amount, composition, condition, and/or productivity of vegetation within specified limits of statistical precision. To be most useful, a quantitative inventory must have a statistically valid sample design, use unbiased sampling methods, and provide both population and reliability estimates (Brewer et al. 2005).

Phase 2 FIA Base-level Inventory

The FIA program of the USDA Forest Service has been in continuous operation since 1930. Their mission is to conduct and continuously update a comprehensive inventory and analysis of the present and prospective conditions of the renewable resources of the forests and rangelands of the United States. This national program consists of five regional FIA units. The Interior West FIA (IWFIA) unit, part of the Rocky Mountain Research Station, conducts inventories throughout NFS Regions 1-4.

Forest lands

Although FIA's mission includes rangeland assessments it is only funded to conduct forest land inventories. The Phase 2 forest inventory consists of permanently established field plots distributed across each state, with a sample intensity of about one plot per 6,000 acres. Field data are collected only on plots where forest land is present. In general, forest land has at least ten percent canopy cover of live tally tree species of any size or has had at least ten percent canopy cover of live tally species in the past; based on the presence of stumps, snags, or other evidence. Each plot consists of a cluster of four subplots that fall within a 144-foot radius circle based on the plot center spread out over approximately 1.5 acres. Most phase 2 data are related to the tree and understory vegetation components of the forest. Plots are distributed on all ownerships across the country and thus will have the number of plots in proportion to the extent of a vegetation type on the landscape. For more details on national FIA please see http://www.fia.fs.fed.us/ or on the FS web at http://fsweb.ogden.rmrs.fs.fed.us/.

All Condition Inventory

As a base-level, quantitative inventory R4 has entered into an agreement with IWFIA to conduct an "All Condition Inventory (ACI)", which collects similar vegetation information on both forest and nonforest lands throughout the region. The ACI is a joint effort initiated by FIA and R1, and adapted for R4 needs. As an extension of the grid-based forest land inventories that FIA conducts on all ownerships throughout the Interior West states, the ACI will result in a consistent and unbiased wall-to-wall inventory on all R4 NFS forest and nonforest lands. Nonforest includes all lands not considered forest land. Thus, the Northern and Intermountain Regions have collaborated with FIA to conduct a seamless inventory with the same data collection protocols on all NFS lands regardless of tree cover. The FIA base-level data are the current focus of this accuracy assessment.

Intensified Inventories (targeted)

If Forest information needs justify further intensification, the R4 intensified inventory protocol can be used to supplement the FIA base grid as a sample targeted for future collection/acquisition. These protocols are similar to FIA design protocols and can be used in conjunction with FIA data to improve estimates and statistical confidence.

Intensified inventories should be spatially unbiased, usually grid-based, and are designed to capture the information needed to supplement the base-line grid. Nevertheless, more samples are often needed in addition to intensified inventory data for accuracy assessment, especially for under-represented classes.

B-Grid

The B-grid is based off the previous 5000-meter “A-grid” periodic design, which was typically used by FIA in the past to intensify by ownership, land type, or reserved status. Generally, the design located plots on a grid 2500-meters offset in the x and y direction from the A-grid. The B-grid has long been implemented on some Region 4 Forests (excludes Caribou-Targhee NF) and is a viable intensification design.

Other

In addition, other intensified grid-based designs can be used by Region 4 Forests and can be modified accordingly for specific purposes. For example, in cooperation with the Remote Sensing Applications Center, Region 4 has generated a systematic grid (independent from the FIA hex-grid) for the purpose of conducting multi-resource inventories to meet Forest planning and management needs. This comprehensive region-wide grid was generated using a hexagonal design having sample locations distributed 1000 meters (in the X, Y directions) where each sample represents approximately 100 hectares (247 acres).

Stratified Random/Systematic (targeted)

Stratified random sample design is usually based on the final vegetation type map, and can be used to collect accuracy assessment or supplemental plots on underrepresented classes that may not have sufficient samples from the base-line or intensified inventory. These plots are usually designed specifically for accuracy assessments or for classes that require more ground-based data. The use of stratified random sampling in conjunction with the systematic base-level inventory is an effective and practical approach for achieving an assessment with increased reliability across vegetation types, and within funding and time constraints.

The Caribou-Targhee NF is in the process of collecting plot data on forest and nonforest lands, which should be available by 2014 and can be used as supplemental data for accuracy assessment. Stratified systematic sample design best describes the design of the supplemental plots on the Caribou-Targhee NF, since not all potential grid points were used in the design. Since most of the Forest Plan(s) Standards and Guidelines are by ecological subsection, the Caribou-Targhee NF was stratified by subsections in order to adequately sample vegetation components (i.e., old growth, sagebrush canopy cover). The initial phases of plot design were limited by budget and needed to be prioritized to meet forest needs. This resulted in differing intensities (by ecological subsections and thus geographic areas) to adequately sample the most important components, while trying to maintain an unbiased random sample. This may present limitations in data analysis, especially if analyzing plots across ecological subsections boundaries or with other baseline data. Forest planning analysis for estimating the habitat distributions will be conducted based on ecological subsections. The plot layout and field data collection protocols followed FIA standards (R4 intensified inventory plot design) and are compatible with FIA baseline data.

In 2012, a total of 120 additional sites were collected in the field using similar data collection procedures as were used for acquiring the training reference site data. These auxiliary sites will provide sufficient data, in combination with the FIA and CT stratified samples, for a future composite baseline-stratified accuracy assessment.

Photo-interpretation (targeted)

Often, a combination of field visits and aerial photo-interpretation can be used to obtain accuracy assessment reference information from the selected sampling scheme. Photo-interpreted sites can be useful for vegetation types or forest canopy cover classes that are easily distinguished using high resolution imagery, especially when used with other ground-based information that can inform the interpreter (e.g., FIA or stratified plots). Photo-interpreted sites can also be an efficient tool for certain canopy cover or other uncommon vegetation classes. Photo-interpretation is also an integral component in the verification and reclassification of an existing or legacy data set having dissimilar plot designs from the map evaluation unit, as in the photo-informed evaluation process of FIA plots used for this assessment.

A sufficient number of reference sites are anticipated to be available from the FIA baseline, Caribou-Targhee NF stratified, and new accuracy assessment stratified samples for a future composite accuracy analysis, however, additional photo-interpreted sites could be collected as needed. For verifying and/or reclassifying the stratified plots, the evaluation and photo-informed procedures used for the reclassification of FIA plots are recommended to maintain consistency of methods across data sets used for accuracy assessment. For all photo interpretations, the acquisition date of the aerial imagery evaluated must be as close as possible to the collection date of satellite imagery used for mapping.

Photo-interpretation is particularly useful in the verification and reclassification process for obtaining a comprehensive evaluation of the broader areas represented by map feature polygons than can feasibly be assessed on the ground. This becomes necessary for checking the homogeneity of a given map evaluation unit (i.e., feature polygon) and the representativeness of field data across its full spatial extent. Estimates for verifying and adjusting tree canopy cover class can be calibrated using the canopy coverage scales and/or aerial photo poster examples developed for the review of field training reference data[14]. In addition, photo-interpretation is very useful for checking the site for signs of landscape changes due to natural or management disturbances (i.e., wildland or prescribed fire, timber harvest, etc.). Interpretations are also essential for identifying and reassigning a plot center (point) to an adjacent map feature for which the majority of the plot data represents.

Ancillary (targeted)

Other useful ancillary reference information includes the Terrestrial Ecological Unit Inventory (TEUI) data, which are used to classify ecological types and map terrestrial ecological units to a consistent standard on NFS lands (Winthers et al., 2005). In addition, National Forest System Field Sampled Stand Exam (FSVeg) data can be useful, along with many other types of field sampled legacy data. As with any existing ground reference data set used for accuracy assessment, the same set of evaluation and photo-informed procedures used for plot verification and/or reclassification are recommended, in order to maintain consistency across data sets used for accuracy assessment.

Methods (FIA base-level)

In general, FIA data can be used for many assessments or as complementary information for other projects. "Mid-level vegetation mapping typically produces three layers of information: dominance type, canopy cover, and tree size. Since the FIA data are a true sample (systematic, random) of these characteristics across the landscape (i.e., a national

[14] See Appendix VII.

forest, county, or state), they can be used in ways that complement the mapping process, or as an independent data set to assess the accuracy of the maps, or both. For mid-level mapping purposes, there are several ways in which the FIA data can be used:

1. Understanding the proportional distributions of forest dominance types and tree sizes across a map project area for map unit design and intermediate map evaluation purposes.
2. Designed-based (e.g., FIA) versus model-based area estimate comparisons of the final map products (non-site specific).
3. Site specific accuracy assessment.

Discussed below are the methods used for area estimates, and for site specific accuracy assessment for this project using the FIA base-level plot data.

Classification of FIA Plots/Conditions for Area Estimates

A non-spatial comparison of designed-based (FIA) vs. model-based (mapped) area outputs is one way of assessing a final map. Designed-based estimates such as FIA provide an excellent source of accuracy assessment information, since it is a true systematic random sample. Discussed below are the steps that were used to stratify, prepare, and classify the FIA data for this purpose.

Stratification for Area Estimates

FIA area expansion factors are the area that an FIA plot represents at the population level and are dependent on many factors (e.g., phase-one stratification, cycle, number of annual panels of data used, or state specific). As a result, area expansion factors for combinations of periodic and varying levels of annual forest/nonforest plot intensities are not supported. Direct use of FIA area expansion factors for stratification are preferred, however, this was not possible on the Caribou-Targhee due to several complicating factors:

1. FIA population evaluations are usually generated at the state level, and the Caribou-Targhee straddles Idaho, Utah, and Wyoming, which have annual data available at varying intensities.
2. Most of the available Wyoming data were from a periodic inventory completed in 2002, since annual inventories were only initiated in Wyoming in 2011.

3. In order to use the most current and complete available data, a mixture of annual inventory intensities in Idaho were used for forest (eight years) and nonforest (10 years) plots.

Due to these complications, FIA generated area estimates could not be used for this project, and stratification was greatly simplified by generating four GIS subpopulations for area estimation. These four subpopulations included separate GIS generated acreage estimates for the Caribou NF in Idaho/Utah, Targhee NF in Idaho, Caribou NF in Wyoming, and Targhee NF in Wyoming. All periodic inventory FIA plots within both Wyoming strata were given equal weight (total GIS area divided by total unadjusted condition proportions). However, Idaho plots were weighted accordingly due to differences in intensities for the forest and the nonforest all condition inventory plots.

Since all strata were considered spatially distributed, unbiased estimates and all data collection protocols were consistent whether forest or nonforest and therefore considered a legitimate unbiased sample of the Forest. There were a total of 433 plot/conditions (some plots have multiple conditions) used for the area estimation from a total of 408 FIA plot locations. Since conditions are considered an area of relatively uniform ground cover, such as a homogenous vegetation cover, they can be mapped and sampled separately; allowing area weights to be assigned using condition proportions.

Data Preparation and Classification

The first step in the data preparation process was data acquisition. Before classification began, it was necessary to join the proper tables, query the data from IWFIA's regional database, and calculate various variables used in this process. Quality control checks were then run on previously populated and vetted statewide national databases to assure that plot-level and condition-level estimates were correct (e.g., live basal area per acre estimates, understory vegetation species and lifeform cover estimates).

The next step was to assign dominance types to the plot/condition-level data. This was the most complicated step, and involved separating plot/conditions into many categories in order to use the appropriate available information for a particular condition's characteristics. This information was used in conjunction with the classification criteria outlined in the Caribou-Targhee Existing Vegetation Keys[15].

[15] See Appendix III.

Species-level FIA canopy cover data were available for all lifeforms except trees. A variable collected on all plots “total live crown cover for all tree species” was used to determine necessary thresholds for forest and woodland dominance types. Basal area (BA) by species was then used to calculate total crown cover by species, and then used with the key. The following summarizes the primary steps involved in assigning vegetation dominance types, tree-size, and crown cover:

Vegetation dominance type steps include:

- Calculate live basal area per acre estimates by species
- Convert to percentages of totals by species
- Identify species with plurality of percent live basal area
- Use live BA percentages as a surrogate in key for identifying species that are the most abundant in terms of relative cover
- Where necessary in key, use total cover to convert to absolute cover
- Determine if plot is non-vegetated; sparse vegetation; sparse tree, shrub or herb; or if it is needed to elevate aggregation to the Forest, Shrubland, Grassland, or Forbland key. The decision depends on the total cover of vascular plants vs. trees vs. potential for sites located in Krummholz vs. relative cover of shrubs, grasses and herbs[16].
- Based on plot/condition information assign the appropriate dominance type , vegetation type, and vegetation group according to key
- Determine if plot data are relevant due to potential disturbance since plot measurement. If it is not relevant, determine other method of assigning dominance type information (imagery, plot photos, notes, etc.)

Tree-Size steps include:

- Calculate live basal area per acre estimates by diameter class by condition
- Convert to percentages of totals by diameter class by species
- Identify diameter class with plurality of percent live basal area
- Assign diameter classes to plot/conditions
- Determine if plot data are relevant due to potential disturbance since plot measurement. If it is not relevant, determine other method of assigning tree-size information (imagery, plot photos, notes, etc.)

[16] See Appendix III.

Canopy cover steps include:

- Use total live tree cover (greater than ten percent) variable to determine forest and woodland conditions
- If total live tree cover is less than ten percent, then use understory veg cover estimates by lifeform and species to determine nonforest cover classes
- Determine if plot data are relevant due to potential disturbance since plot measurement. If it is not relevant, determine other method of assigning crown or shrub cover information (imagery, plot photos, notes, etc.)

After stratification, data preparation, and classification were finished, plot/condition area information were ready for summarizing for comparisons to mapped area estimates.

Re-classification of FIA Plots for Accuracy Assessments (Site Specific)

Another use for the FIA base-level grid plots is for conducting site-specific accuracy assessments on existing vegetation mid-level map products. This accuracy assessment was called a *re-classification* to easily help distinguish it from the design versus model based area estimates, and the site-specific accuracy assessment. All plots on the FIA base-level grid were used for this assessment. This was necessary so that the systematic, unbiased nature of the grid was not compromised. Primarily this re-classification was done by evaluating the FIA plot (subplot 1 center) with the spatially coincident mapped polygon feature. The "unit of evaluation" for the FIA plot was the 144-foot radius area (1.5 acre) encompassing the four 1/24th acre fixed radius subplots used for vegetation sampling. The unit of evaluation for the map or "mapped polygon feature" was the resulting polygon from the union of the vegetation type map features, the tree-size map features, and the canopy cover map features. See Figure 9 for example of FIA plot area with mapped-polygon features and segments. Segments (yellow boundaries) consist of landscape pattern delineation polygons (generated from high resolution imagery) that are used as the spatial units for vegetation modeling and attribution.

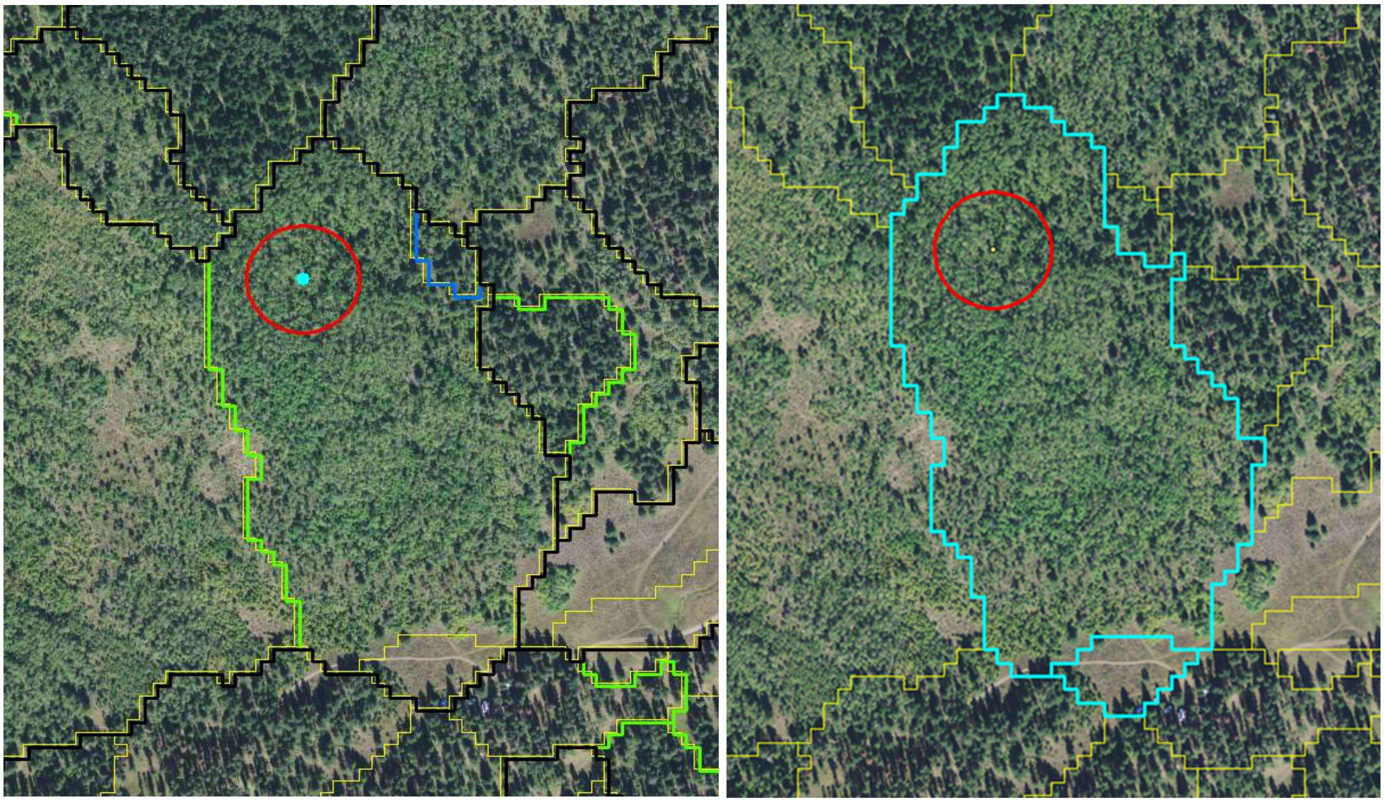

Figure 9: The photograph (0.5-meter resource imagery, 2009) to the left is an example of an FIA plot with the 144-foot radius (red circle) sampling footprint that contains the four 1/24th acre fixed subplots used for sampling vegetation, with an overlay of mapped polygon boundaries. The mapped polygon boundaries comprise the union of the vegetation type, tree-size, and crown cover map features. Black boundaries display vegetation type delineations, blue boundaries are tree-size delineations, green boundaries are crown cover delineations, and yellow boundaries are segments. The photograph to the right shows the same FIA plot with the unit of evaluation highlighted in blue (2 polygons).

The union of these three layers (unlike segments) allowed a more appropriate area to be evaluated with the FIA plots, since it is more similar to the mapping result of the three most important variables used in distinguishing vegetation conditions or stands sampled by field crews on the ground.

It was determined that to best portray the map accuracy, the assessment would be performed on the final map features, and not the intermediate modeled segments, which serve as the building blocks for the final product. This resulted in polygons that were either at a minimum the same size as the segments, but more often larger, which allowed more of the FIA plots to fit entirely within an evaluation unit and reduced the number of FIA plots that straddled segments. Consequently, some polygons were quite large, which sometimes required the plot data to be interpreted rather than used directly. Due to the inherent differences between the FIA sample design and map characteristics, and since all FIA plots were included in this assessment, the FIA sample design (e.g., size of plot), the field data collection protocols, and the defining attributes (forest type, tree size, tree cover density, etc.) associated with FIA vegetation condition boundaries were often not in alignment with the size or characteristics of the mid-level mapped polygon boundaries. As a result, the FIA data could not always be directly applied to the mapped polygons. This made it very important to document how the FIA plot information was used during the re-classification process and will be critical for subsequent evaluations and for developing a standardized Regional accuracy assessment protocol (Table 16).

Table 16: FIA plot/mapped polygon documentation relationship codes and descriptions. The table shows the five variables used to document how each FIA plot was evaluated along with its associated mapped polygon. Each of the five variables had from two to six possible codes that were independently evaluated for each FIA plot.

FIA Plot/Mapped Polygon Relationship Codes*	Code descriptions (only one set of codes per plot-e.g.condition level data is used only for FIA area proportion estimates and not accuracy assessments)
FIA Plot Within Polygon Code	
1	FIA plot area (144' radius) 75%+ within mapped polygon
2	FIA plot area (144' radius) <75% within mapped polygon
FIA Condition Code	
1	One condition FIA plot
2	Multi-condition FIA plot
FIA Plot Representative Code	
1	FIA plot is representative of mapped polygon based on vegetation map unit, tree-size class, and canopy cover class
2	FIA plot is **not** representative of mapped polygon based on vegetation map unit, tree-size class, and canopy cover class
Mapped Polygon Homogeneity Code	
1	Overall the mapped polygon is considered to be homogenous in terms of vegetation map unit, tree-size class, and canopy cover class
2	Overall the mapped polygon is **not** considered to be homogenous in terms of vegetation map unit, tree-size class, and canopy cover class
3	Mapped polygon is too large too be considered homogenous E.g. usually greater than 160 acres
FIA Plot Data Evaluation Type Code	
1	Use FIA data directly--use all four subplots (plot), or condition level data, or subplot level data
2	Same as code 1 only adjusted crown cover according to imagery (e.g. fia cover data not directly used)
3	Photo-interpret using FIA plot data as reference only (this code similar to Region 1). Also used when major disturbance to FIA plot since plot measurement
4	FIA-grid locational photo-interpretation only (no FIA data available for plot-e.g. innaccessible, denied access, sample missed, etc.)
5	Move the FIA plot evaluation to a more appropriate polygon (ploygon must border poly that plot falls within)
6	Field Visit - FIA plot data not used
*Note: Mapped Polygons are actually the union of the vegetation map unit, tree-size class, and canopy crown cover class layers	

Results (FIA Base-level)

Classification of FIA Plots/Conditions for Area Estimates

The classification of FIA plots/conditions for estimating area estimates was performed on FIA base-level plots, resulting in estimates for vegetation group area, vegetation type area, tree size, and canopy cover (tree and shrub).

Area Estimates Based on FIA Base-level Plots

The source data set for this analysis was approximately eight years (2004-2011) of *forest* and ten years (2004-2013) of *nonforest* FIA annual inventory plots in Idaho on the Caribou-Targhee NF. For the Wyoming portion of the Caribou-Targhee, the most current periodic inventory (2002) was used for area estimates along with one subcycle (2011) of annual plot data used to replace a small portion of the older periodic plots. This was done in order to use the most current plot data available for all estimates.

There were a total of 433 plot/conditions available for area estimation from a total of 408 FIA plot locations. Since some plots have more than one forest condition, condition-level plot data was used for area estimates. While the area classification focused primarily on the condition level data, the site-specific re-classification accuracy assessment focused on plot level information and its spatial relationship to the mapped polygons.

Below are the FIA summarized results for predicted area, percent area, and number of plot/conditions by the five map attributes, including vegetation group, vegetation type, tree-size, tree canopy cover, and shrub canopy cover.

Vegetation Group FIA Area Estimates

Table 17 below shows the results for vegetation group for the Caribou-Targhee. Approximately 75 percent of the Forest is in forest and woodland groups and about 25 percent in nonforest. Conifer forest (53 percent) is by far the largest group, with deciduous forest at 13 percent and woodland at nine percent. Shrubland (19 percent) is the second largest vegetation group, with the remaining nonforest groups totaling less than six percent.

Table 17: Total area (acres), percent of total area, and number of plot/conditions by forest/nonforest and vegetation group, Caribou-Targhee National Forest.

Forest/Nonforest Vegetation Group	Vegetation Group	Area	Percent area	Number of plot/conditions (n)
Forest and woodland	Conifer Forest	1,542,926	53.3%	222
	Deciduous Forest	383,274	13.2%	58
	Woodland	250,804	8.7%	38
Forest and woodland Total		**2,177,004**	**75.2%**	**318**
Nonforest	Shrubland	555,574	19.2%	89
	Herbaceous	65,787	2.3%	11
	Alpine	35,088	1.2%	5
	Barren/Sparse Vegetation	33,445	1.2%	5
	Non-Vegetated	23,673	0.8%	4
	Riparian	6,117	0.2%	1
Nonforest		**719,685**	**24.8%**	**115**
Grand Total		**2,896,689**	**100.0%**	**433**

Vegetation Type FIA Area Estimates

Table 18 below shows the results for vegetation type for the Caribou-Targhee. Douglas-fir is the largest map unit at approximately 15 percent, followed by lodgepole pine (14 percent), mountain big sagebrush (12 percent), conifer mix (10 percent), and spruce/fir (7 percent). The remaining map units all have less than six percent each. Three map units had no classified FIA samples (riparian shrublands/deciduous tree, agriculture, and developed), which reflects the relative scarcity of occurrence of these types across the area.

Table 18: Total area (acres), percent of total area, and number of plot/conditions by forest/nonforest and vegetation type, Caribou-Targhee National Forest.

Forest/Nonforest Vegetation Group	Vegetation Type	Area	Percent area	Number of plot/conditions (n)
Forest and woodland	Douglas-fir	440,249	15.2%	67
	Lodgepole Pine	389,840	13.5%	60
	Conifer Mix	286,423	9.9%	36
	Spruce/Fir	209,861	7.2%	30
	Conifer/Aspen	159,456	5.5%	24
	Aspen	152,273	5.3%	24
	Douglas-fir/Lodgepole Pine	134,971	4.7%	18
	Juniper mix	93,875	3.2%	15
	Bigtooth Maple mix	88,147	3.0%	13
	Aspen/Conifer	71,545	2.5%	10
	Mountain Mahagony Mix	68,783	2.4%	10
	Limber Pine/Douglas-fir	48,508	1.7%	7
	Whitebark Pine mix	33,074	1.1%	4
Forest and woodland Total		**2,177,004**	**75.2%**	**318**
Nonforest	Mountain Big Sagebrush	334,772	11.6%	54
	Forest/Mountain Shrublands	170,573	5.9%	27
	Barren/Sparse Vegetation	39,562	1.4%	6
	Alpine Vegetation	35,088	1.2%	5
	Dry Big Sagebrush Mix	32,230	1.1%	5
	Montane Herbaceous	28,265	1.0%	4
	Subalpine Herbaceous	22,734	0.8%	4
	Dwarf Sagebrush	17,999	0.6%	3
	Water	17,556	0.6%	3
	Ruderal Grasslands	14,788	0.5%	3
	Riparian Herbaceous	6,117	0.2%	1
Nonforest Total		**719,685**	**24.8%**	**115**
Grand Total		**2,896,689**	**100.0%**	**433**

Tree-size FIA Area Estimates

Table 19 shows the results for tree-size classes for the Caribou-Targhee. Forest classes begin with "F", and are for species measured for diameter at breast height (DBH). Woodland classes begin with "W", and are for species measured for diameter at root collar (DRC). Tree-size F-TS2 (48 percent) was the most common map unit on the Caribou-Targhee, followed by F-TS3 (24 percent) and F-TS1 (17 percent). The most common woodland tree-size class was W-TS2 at five percent.

Table 19: Total area (acres), percent of total area, and number of plot/conditions by tree-size class for forest and woodland, Caribou-Targhee National Forest.

Tree-size class	Area	Percent area	Number of plot/conditions (n)
F-TS2 (7.0-15.9" DBH)	1,051,849	48.3%	148
F-TS3 (16.0"+ DBH)	514,830	23.6%	76
F-TS1 (0-6.9" DBH)	359,520	16.5%	56
W-TS2 (7.0-15.9" DRC)	109,726	5.0%	18
W-TS1 (0-6.9" DRC)	71,601	3.3%	9
W-TS3 (16.0"+ DRC)	69,477	3.2%	11
Grand Total	**2,177,004**	**100.0%**	**318**

Tree Canopy Cover FIA Area Estimates

Table 20 shows the results for tree canopy cover for the Caribou-Targhee. The most common tree cover map unit was TC1 (41 percent), followed by TC2 (32 percent), TC3 (11 percent), and TC4 (11 percent). The minimum threshold for forest and woodland cover classes is ten percent. Where canopy cover is less than ten percent cover of trees, the plots would be assigned a nonforest class.

Table 20: Total area (acres), percent of total area, and number of plot/conditions by tree cover class for forest and woodland, Caribou-Targhee National Forest.

Tree canopy class	Area	Percent area	Number of plot/conditions (n)
TC1 (10-29%)	898,271	41.3%	127
TC2 (30-49%)	704,816	32.4%	98
TC3 (50-59%)	244,444	11.2%	38
TC4 (60-69%)	241,216	11.1%	36
TC5 (70%+)	88,257	4.1%	19
Grand Total	**2,177,004**	**100.0%**	**318**

Shrub Canopy Cover FIA Area Estimates

Table 21 shows the results for shrub canopy cover for the Caribou-Targhee. The most common shrub cover map unit was SC3 (55 percent), followed by SC2 (22 percent) and SC1 (14 percent). The minimum threshold for shrubland cover classes is ten percent. Below ten percent cover of shrubs would be assigned to another nonforest class.

Table 21: Total area (acres), percent of total area, and number of plot/conditions by shrub cover class for shrubland, Caribou-Targhee National Forest.

Shrub canopy class	Area	Percent area	Number of plot/conditions (n)
SC3 (25-49%)	304,878	54.9%	50
SC2 (15-24%)	123,456	22.2%	19
SC1 (10-14%)	75,016	13.5%	11
SC4 (50 %+)	52,224	9.4%	9
Grand Total	**555,574**	**100.0%**	**89**

Mapped Area Estimates

To facilitate direct comparisons with FIA, mapped estimates include only Caribou-Targhee NF administered lands and do not include private lands or other owner in-holdings. Note: the total mapped FIA Caribou-Targhee area (2,896,199 acres) is about 490 acres less than the FIA plot estimates (2,896,689 acres), although percent areas by class are still directly comparable.

Below are the summarized mapped results for predicted area and percent area by the five map attributes.

Vegetation Group Mapped Area Estimates

Table 22 shows the results for the vegetation group for the Caribou-Targhee. Approximately 73 percent of the Forest is in forest and woodland map groups and about 27 percent in nonforest map groups. Conifer forest (52 percent) is by far the largest map group, with deciduous forest at 14 percent and woodland at six percent. Shrubland (20 percent) is the second largest map group with the remaining nonforest map groups totaling less than eight percent.

Table 22: Total area (acres) and percent of total area by forest/nonforest and vegetation group, Caribou-Targhee National Forest.

Forest/Nonforest Vegetation Group	Vegetation Type	Area	Percent area
Forest and woodland	Conifer forest	1,513,135	52.2%
	Deciduous forest	417,427	14.4%
	Woodland	174,528	6.0%
Forest and woodland Total		**2,105,091**	**72.7%**
Nonforest	Shrubland	564,075	19.5%
	Herbaceous	98,716	3.4%
	Barren/Sparsely Vegetated	51,432	1.8%
	Riparian	30,018	1.0%
	Alpine	25,898	0.9%
	Non-Vegetated	20,969	0.7%
Nonforest Total		**791,108**	**27.3%**
Grand Total		**2,896,199**	**100.0%**

Vegetation Type Mapped Area Estimates

Table 23 shows the results for the vegetation type classes for the Caribou-Targhee. Douglas-fir is the largest map unit at approximately 20 percent, followed by lodgepole pine (16 percent), mountain big sagebrush (15 percent), conifer mix (8 percent), and aspen (8 percent). The remaining map units all have less than five percent each.

Table 23: Total area (acres) and percent of total area by forest/nonforest and vegetation type, Caribou-Targhee National Forest.

Forest/nonforest Vegetation Group	Vegetation Type	Area	Percent area
Forest and Woodland	Douglas-fir	574,911	19.9%
	Lodgepole Pine	460,550	15.9%
	Conifer Mix	218,531	7.5%
	Aspen	218,152	7.5%
	Spruce/Fir	122,706	4.2%
	Conifer/Aspen	115,549	4.0%
	Bigtooth Maple mix	86,905	3.0%
	Aspen/Conifer	83,726	2.9%
	Mountain Mahagony Mix	60,477	2.1%
	Douglas-fir/Lodgepole Pine	55,519	1.9%
	Limber Pine/Douglas-fir	51,877	1.8%
	Whitebark Pine mix	29,041	1.0%
	Juniper mix	27,147	0.9%
Forest and Woodland Total		**2,105,091**	**72.7%**
Nonforest	Mountain Big Sagebrush	422,008	14.6%
	Forest/Mountain Shrublands	77,031	2.7%
	Barren/Sparse Vegetation	51,432	1.8%
	Subalpine Herbaceous	44,572	1.5%
	Montane Herbaceous	34,622	1.2%
	Dwarf Sagebrush	33,623	1.2%
	Dry Big Sagebrush Mix	31,414	1.1%
	Riparian Shrublands/Deciduous Tree	26,027	0.9%
	Alpine Vegetaton	25,898	0.9%
	Ruderal Grasslands	19,522	0.7%
	Water	17,768	0.6%
	Riparian Herbaceous	3,991	0.1%
	Developed	2,542	0.1%
	Agriculture	659	0.0%
Nonforest Total		**791,108**	**27.3%**
Grand Total		**2,896,199**	**100.0%**

Tree-size Mapped Area Estimates

Table 24 shows the results for tree-size map classes for the Caribou-Targhee. Tree-size F-TS2 (54 percent) was the most common on the Caribou-Targhee, followed by F-TS1 (21 percent) and F-TS3 (17 percent). The most common woodland tree-size class was W-TS2 at five percent.

Table 24: Total area (acres) and percent of total area by tree-size class for forest and woodland classes, Caribou-Targhee National Forest.

Tree-size class	Area	Percent area
F-TS2 (7.0-15.9" DBH)	1,126,501	53.5%
F-TS1 (0-6.9" DBH)	440,773	20.9%
F-TS3 (16.0"+ DBH)	363,289	17.3%
W-TS2 (7.0-15.9" DRC)	93,964	4.5%
W-TS1 (0-6.9" DRC)	66,769	3.2%
W-TS3 (16.0"+ DRC)	13,795	0.7%
Grand Total	**2,105,091**	**100.0%**

Tree Canopy Cover Mapped Area Estimates

Table 25 shows the results for tree canopy cover map classes for the Caribou-Targhee. The most common tree cover class was TC1 (36 percent), followed by TC2 (32 percent) and TC3 (17percent).

Table 25: Total area (acres) and percent of total area by tree cover class for forest and woodland, Caribou-Targhee National Forest.

	Values	
Tree canopy class	Area	Percent area
TC1 (10-29%)	755,049	35.9%
TC2 (30-49%)	667,124	31.7%
TC3 (50-59%)	362,348	17.2%
TC4 (60-69%)	205,276	9.8%
TC5 (70%+)	115,294	5.5%
Grand Total	**2,105,091**	**100.0%**

Shrub Canopy Cover Mapped Area Estimates

Table 26 below shows the results for shrub canopy cover map classes for the Caribou-Targhee. The most common shrub cover class was SC3 (50 percent), followed by SC2 (20 percent) and SC1 (17 percent).

Table 26: Total area (acres) and percent of total area by shrub cover class for shrubland, Caribou-Targhee National Forest.

	Values	
Shrub canopy class	**Area**	**Percent area**
SC3 (25-49%)	293,405	49.7%
SC2 (15-24%)	118,245	20.0%
SC1 (10-14%)	99,234	16.8%
SC4 (50 %+)	79,218	13.4%
Grand Total	**590,102**	**100.0%**

Comparisons of Mapped to FIA Area Estimates

In general, map units with many classes such as vegetation type tend to have more discrepancies in the mapped versus the area estimates of occurrence. This is probably due to more and finer thresholds potentially confusing recognition of class spectral signatures, and may also be due to limitations in the number of accuracy assessment sites available from FIA plots. It should also be noted that other map units with few classes (such as tree-size or canopy cover) are typically difficult to map accurately.

Following are comparisons of FIA and mapped percentage of occurrence for total area results by the five map attributes.

Vegetation Group Comparisons

Figure 10 below shows the results for vegetation group for the Caribou-Targhee. In general, agreement between FIA and mapped predicted areas are good for vegetation group, and as expected, the most common map groups such as conifer forest, shrubland, and deciduous forest have the best results. Considering relative (not absolute) differences in predicted areas, woodland (38 plots/conditions) and herbaceous (11 plot/conditions) groups had the largest differences. Comparisons for the remaining map groups are not recommended due to small sample sizes (<10 plot/conditions).

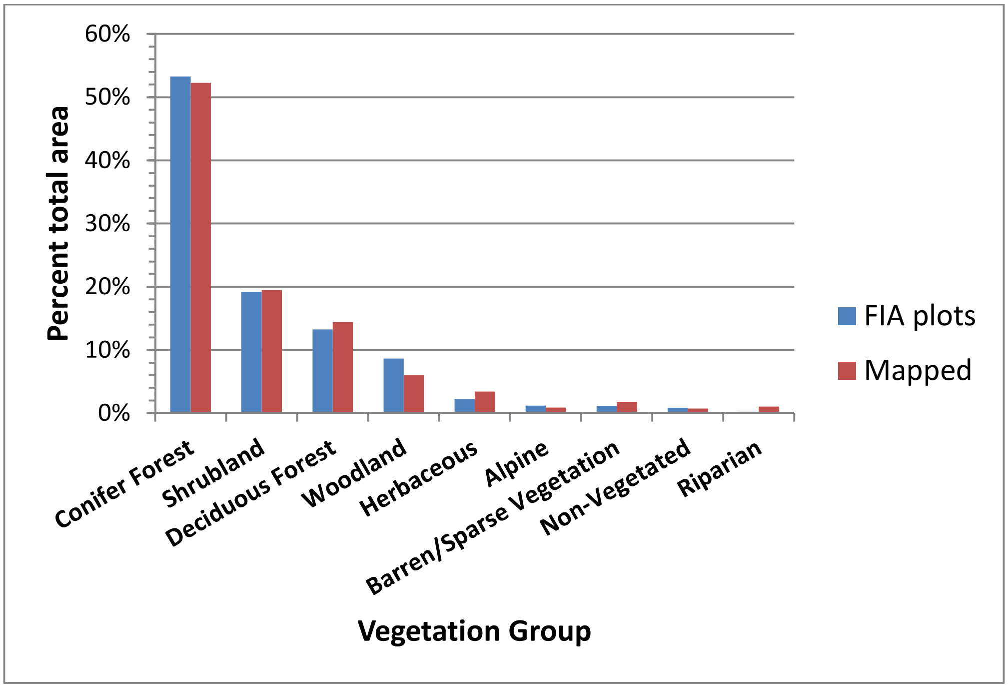

Figure 10: Comparison of percent total area estimates from FIA plots and the map for vegetation group, Caribou-Targhee National Forest.

Vegetation Type Comparisons

Figure 11 shows the predicted FIA and mapped percent total area for vegetation type on the Caribou-Targhee. There was good agreement between FIA and the map for forest and woodland map units combined, and nonforest map units combined, with only a two percent difference, nevertheless, there were some notable differences in total percent area for some of the ten most common map units. As seen in Figure 13 (which is similar to Figure 11 but shows only the percent area difference between FIA and mapped), Douglas-fir had the largest absolute difference at -4.7 percent, with significantly more area mapped than predicted by FIA. This was followed by forest and mountain shrublands (3.2 percent), mountain big sagebrush (-3.0 percent), and spruce-fir (3.0 percent). Considering the relative occurrence predicted by FIA, juniper mix and Douglas-fir/lodgepole had notably smaller areas predicted by the map. Comparisons for map units with less than ten FIA plot/conditions are not recommended.

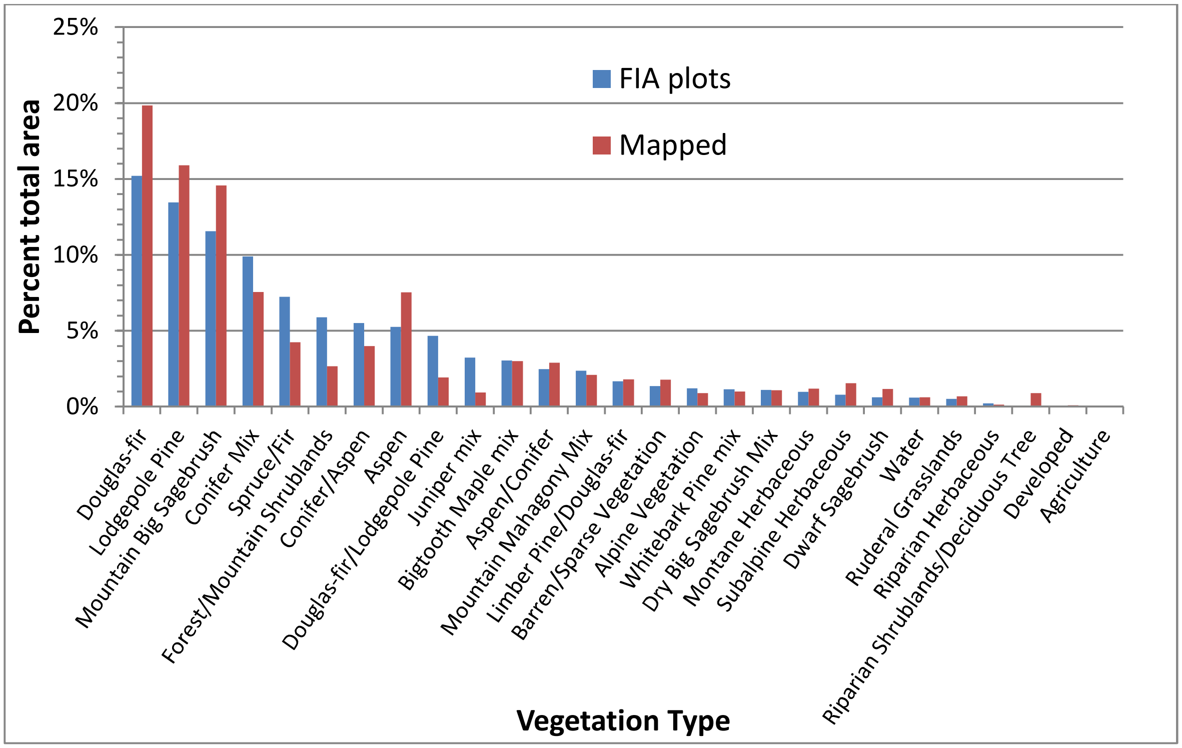

Figure 11: Comparison of percent total area estimates for FIA plots and the map by vegetation type, Caribou-Targhee National Forest.

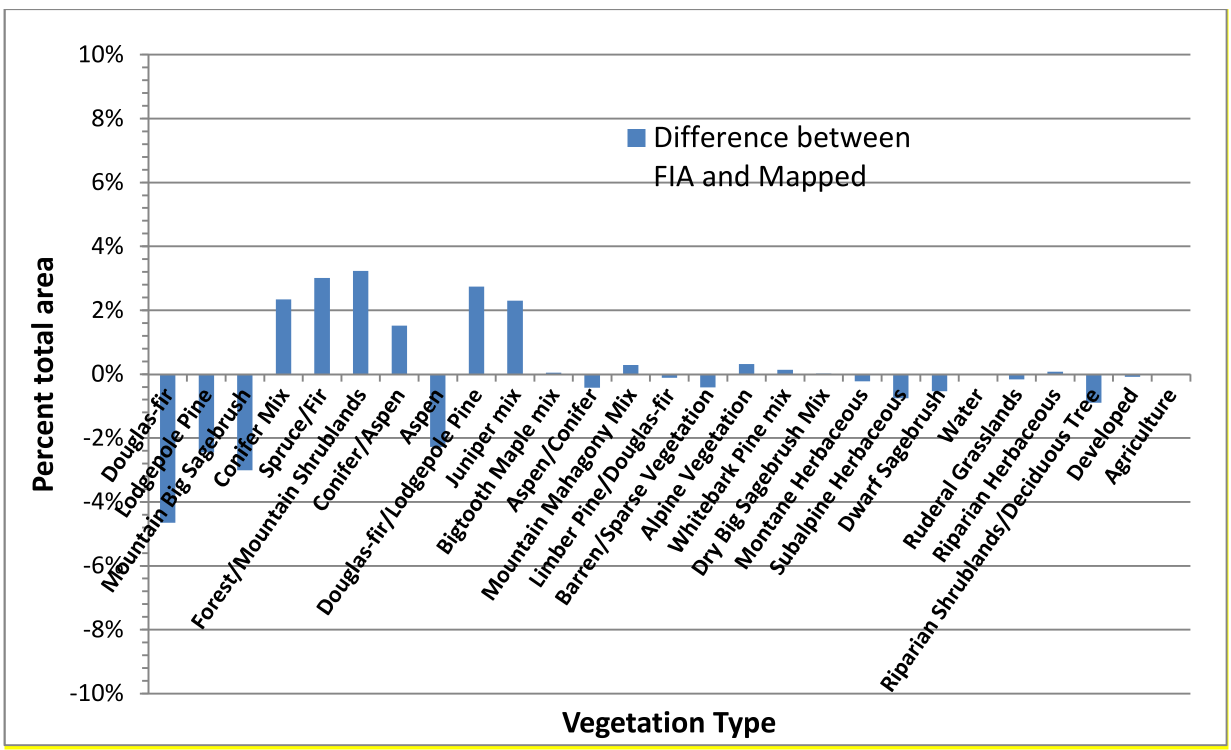

Figure 12: Comparison of the difference in percent total area from FIA plots and the map for vegetation type, Caribou-Targhee National Forest.

Tree-size Comparisons

Figure 13 shows the results for tree-size class for the Caribou-Targhee. The F-TS2 class was the largest for both FIA and the map, and had relatively good agreement (within ten percent of each other). Excluding W-TS3, the largest relative difference was in the F-TS3 class, followed by the F-TS1 class. Although both were small classes, the W-TS2 and W-TS1 had good agreement.

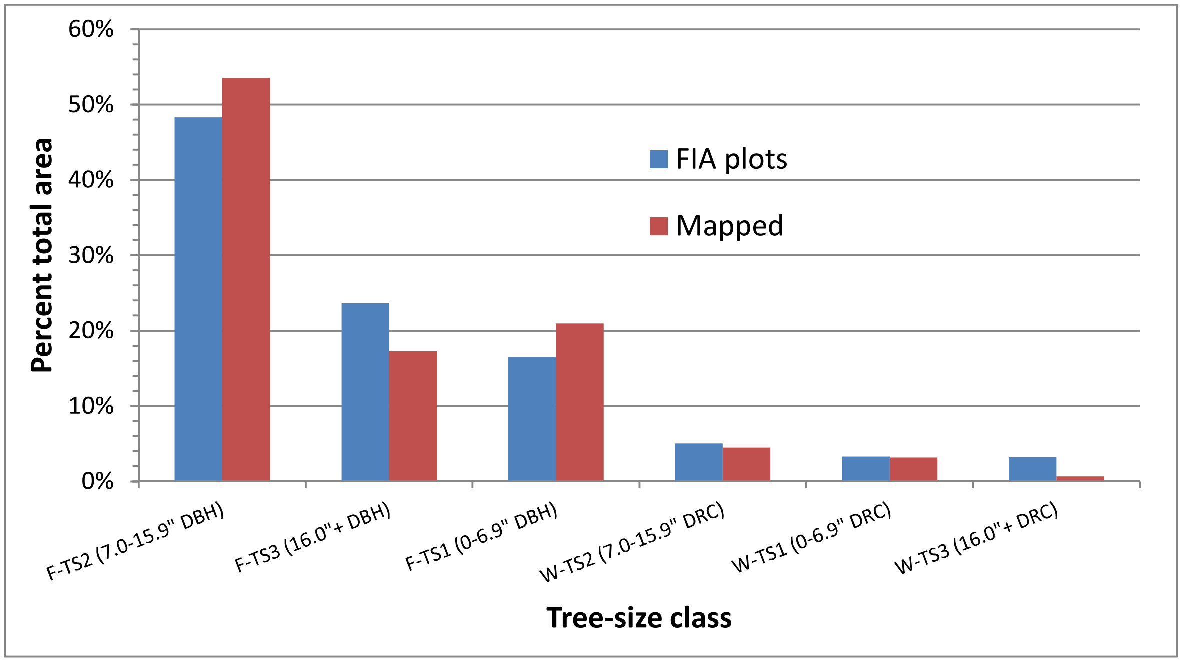

Figure 13: Comparison of percent total area estimates from FIA plots and the map by tree-size class for forest and woodland, Caribou-Targhee National Forest.

Tree Canopy Cover Comparisons

Figure 14 shows the results for tree cover class for the Caribou-Targhee. The TC1 class was the largest for both FIA and the map, and had relatively good agreement. The next largest class was TC2 with good agreement. The largest relative difference was in TC3 class.

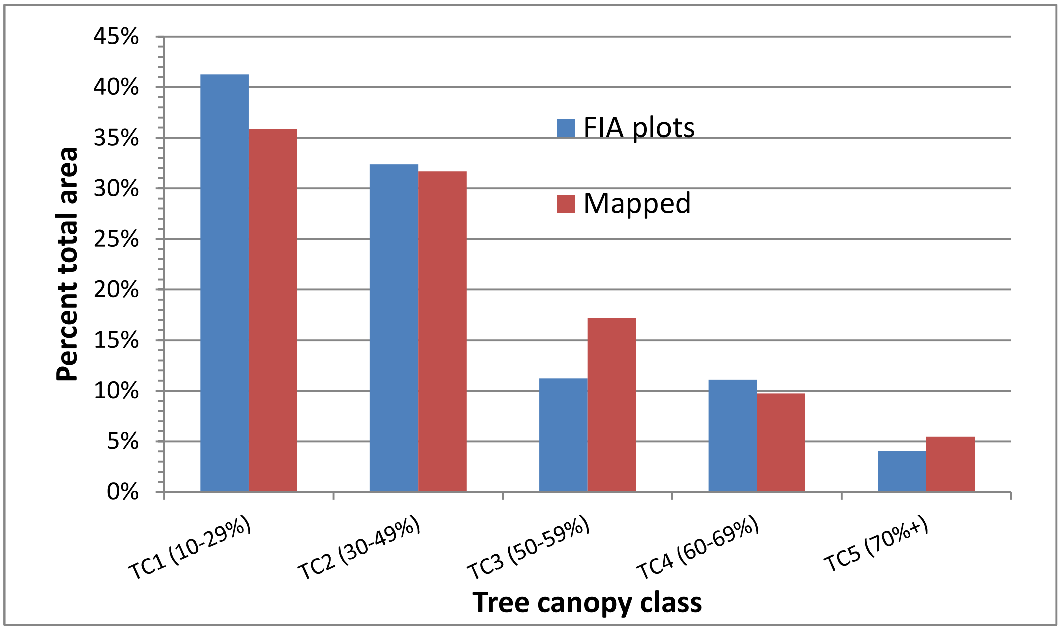

Figure 14: Comparison of percent total area estimates from FIA plots and the map by tree cover class for forest and woodland, Caribou-Targhee National Forest.

Shrub Canopy Cover Comparisons

Figure 15 shows the results for shrub cover class for the Caribou-Targhee. The SC3 class was the largest for both FIA and the map, and had relatively good agreement. The next largest class, (SC2) showed good agreement. The SC4 class had the largest relative difference.

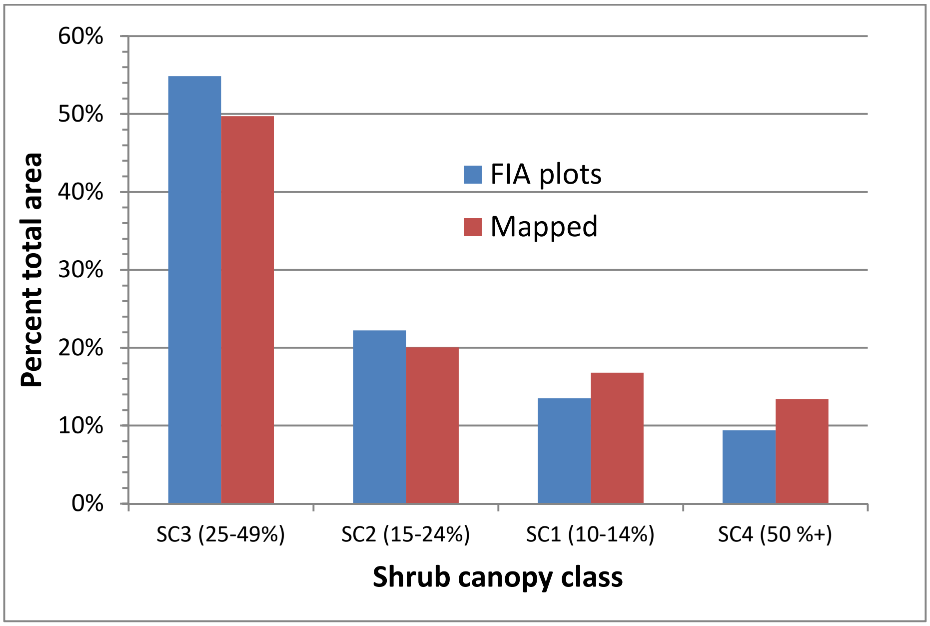

Figure 15: Comparison of percent total area estimates from FIA plots and the map by shrub cover class for shrubland, Caribou-Targhee National Forest.

Re-classification of FIA plots for Accuracy Assessments (Site Specific)

Accuracy assessments are an essential part to any remote sensing project, used not only for comparing different mapping methods and sensors, but also for providing information on the reliability and usefulness of remote sensing techniques for a particular application. Most importantly, accuracy assessments support the mapped information used in the decision making process by providing a measure of the reliability of the mapped classes, and allowing users to understand the map limitations (Nelson et al., in press).

The Error Matrix

The error (confusion) matrix is a standard tool used for presenting results of an accuracy assessment. In general, it is a square array where both the classified reference (observed) and image (mapped) data are ordered and compared for class agreement on the diagonally intersected cells; typically rows in the matrix represent the classified image data and columns the reference data (Story and Congalton 1986). The error matrix can be used to determine the accuracy of classes and to what degree classes are confused with each other. Table 27 is an example of an error matrix for vegetation group for the Caribou-Targhee. In this table, the *observed* classes (FIA plots) are presented in the rows and the *mapped* classes in the columns. The highlighted diagonal cells tally the number of FIA plots that are in agreement with the intersected mapped classes. Percent class accuracies are calculated by dividing the number of correct classifications (diagonal cells) by each class total. For each class there are two main types of accuracies generated by the error matrix. "User's Accuracy" indicates errors of commission; this is where a class has been mapped in places where it does not exist. "Producer's Accuracy" indicates errors of omission; this is where a class has not been mapped but exists on the ground.

The shrubland vegetation group had the highest producer's accuracy at 94 percent, followed by conifer forest at 92 percent (Table 27). The riparian vegetation group had the highest user's accuracy at 100 percent, although only one plot was mapped as riparian. Shrubland had the next highest user's accuracy at 92 percent, followed by conifer forest at 87 percent. The overall user's and producer's accuracy for vegetation group was 83 percent.

Table 27: Error matrix showing User's (percent) and Producer's (percent) Accuracies for vegetation group classes on the Caribou-Targhee.

Observed Vegetation Group Classes	Mapped Vegetation Group Classes									Producer's Accuracy
	Conifer Forest	Shrubland	Deciduous Forest	Woodland	Non Vegetated	Herbaceous	Alpine Vegetation	Riparian	Grand Total	
Conifer Forest	186		14	2		1			203	91.6
Shrubland	1	77	1	1		1	1		82	93.9
Deciduous Forest	20	2	36	2					60	60.0
Woodland	6	1	8	22					37	59.5
Non Vegetated					8	2			10	80.0
Herbaceous	1	4				4			9	44.4
Alpine Vegetation			1	1			3		5	60.0
Riparian						1		1	2	50.0
Grand Total	214	84	60	28	8	9	4	1	408	82.6
User's Accuracy	86.9	91.7	60.0	78.6	100.0	44.4	75.0	100.0	82.6	

Overall User's and Producer's Accuracy Results

Table 28 summarizes the overall re-classification accuracies for the Caribou-Targhee. As in Table 18 through Table 28, this analysis was done using a deterministic (where only primary calls were considered correct) assessment. As expected, of the 408 FIA plots available for the re-classification, the vegetation group had the highest overall accuracy at 83 percent, followed by tree-size class at 62 percent, vegetation type at 56 percent, and canopy cover class at 45 percent. Results for subsets (<408 plots) of the re-classification data for tree-size and canopy cover are also presented in Table 28.

Table 28: User's (percent) and Producer's (percent) overall accuracy by number of observed and mapped FIA plots and summary type.

Summary Type	Number of Observed FIA Base-level Plots	Producer's Accuracy	Number of Mapped FIA Base-level Plots	User's Accuracy
Vegetation Group	408	82.6	408	82.6
Vegetation Map Unit	408	55.9	408	55.9
Tree-size Class (includes non-tree classes)	408	62.3	408	62.3
Tree-size Class (includes only tree classes)	300	50.7	302	50.3
Canopy Cover Class (includes non-cover classes)	408	45.1	408	45.1
Canopy Cover Class (only cover classes)	382	43.2	386	42.7
Tree Canopy Class	300	41.7	302	41.4
Shrub Canopy Class	82	48.8	84	47.6

Class User's and Producer's Accuracy Results

Table 29 through Table 32 below show the detailed user's and producer's accuracy results for vegetation group, vegetation type, tree-size class, and canopy cover class. Table 29 shows the user's and producer's accuracy results and number of FIA plots by detailed classes for vegetation group. In general, the conifer forest map group had the highest number of observed (203 plots) and mapped (214 plots) classes, followed by shrubland and deciduous forest. For map groups with greater than ten observed plots, user's and producer's accuracies were the highest for the shrubland map group, followed by conifer forest and woodland. The herbaceous map group had the lowest user's accuracy followed by deciduous forest and alpine vegetation.

Table 29: User's (percent) and Producer's (percent) accuracy by number of FIA plots for vegetation group.

Vegetation Group	Number of Observed FIA Base-level Plots	Producer's Accuracy	Number of Mapped FIA Base-level Plots	User's Accuracy
Conifer Forest	203	91.6	214	86.9
Shrubland	82	93.9	84	91.7
Deciduous Forest	60	60.0	60	60.0
Woodland	37	59.5	28	78.6
Non Vegetated	10	80.0	8	100.0
Herbaceous	9	44.4	9	44.4
Alpine Vegetation	5	60.0	4	75.0
Riparian	2	50.0	1	100.0
Grand Total	**408**	**82.6**	**408**	**82.6**

Table 30 shows the user's and producer's accuracy results, and the number of FIA plots by detailed classes for vegetation type. In general, the Douglas-fir map class had the highest number of observed (61) and mapped (84) plots, followed by mountain big sagebrush (56 observed) and lodgepole pine (49 observed).

For map units with greater than five observed plots, producer's accuracies were the highest for the mountain big sagebrush class (88 percent), followed by lodgepole pine at 86 percent, barren/sparse vegetation at 75 percent, and aspen at 74 percent; and the lowest for the conifer/aspen class (9 percent), followed by Douglas-fir/lodgepole pine at 12 percent, and aspen/conifer at 13 percent.

For map units with greater than five mapped plots, user's accuracies were the highest for the barren/sparsely vegetated class at 100 percent, followed by mountain big sagebrush at 77 percent, bigtooth maple mix at 67 percent, and lodgepole pine at 61 percent; and the lowest for the conifer/aspen map class at 11 percent, followed by aspen/conifer at 18 percent, and Douglas-fir/lodgepole pine at 29 percent.

Table 30: User's (percent) and Producer's (percent) accuracy by number of FIA plots for vegetation type.

Vegetation Type	Number of Observed FIA Base-level Plots	Producer's Accuracy	Number of Mapped FIA Base-level Plots	User's Accuracy
Alpine Vegetation	5	60.0	4	75.0
Aspen	23	73.9	31	54.8
Aspen/Conifer	15	13.3	11	18.2
Barren/Sparse Vegetation	8	75.0	6	100.0
Bigtooth Maple mix	15	66.7	15	66.7
Conifer Mix	38	34.2	29	44.8
Conifer/Aspen	22	9.1	18	11.1
Douglas-fir	61	72.1	83	53.0
Douglas-fir/Lodgepole Pine	17	11.8	7	28.6
Dry Big Sagebrush Mix	5	60.0	4	75.0
Dwarf Sagebrush	3	100.0	3	100.0
Forest /Mountain Shrublands	18	33.3	13	46.2
Juniper mix	14	28.6	4	100.0
Limber Pine/Douglas-fir	6	50.0	4	75.0
Lodgepole Pine	49	85.7	69	60.9
Montane Herbaceous	4	25.0	4	25.0
Mountain Big Sagebrush	56	87.5	64	76.6
Mountain Mahagony Mix	8	50.0	9	44.4
Riparian Herbaceous	2	50.0	1	100.0
Ruderal Grasslands	2	100.0	3	66.7
Spruce/Fir	28	25.0	19	36.8
Subalpine Herbaceous	3	33.3	2	50.0
Water	2	100.0	2	100.0
Whitebark Pine mix	4	25.0	3	33.3
Grand Total	**408**	**55.9**	**408**	**55.9**

Table 31 shows the user's and producer's accuracy results and number of FIA plots by detailed classes for tree-size. Tree-size classes are separated by forest (F) or diameter at breast height (DBH) species, and woodland (W) or diameter at root collar (DRC) species, and each have three classes: TS-1 is from 0-6.9 inches diameter, TS-2 is from 7.0-15.9 inches diameter, and TS-3 is 16.0 inches and greater diameter.

In general, for tree-size classes other than NTS (no tree size), the F-TS2 class had the highest number of observed (148) and mapped (173) plots, followed by F-TS3 and F-TS1. Producer's accuracies were the highest for the W-TS1 at 67 percent, followed by F-TS2 at 66 percent and W-TS2 at 41 percent; and the lowest for the W-TS3 at nine percent, followed by F-TS3 at 23 percent. Producer's accuracies for tree-size class were very similar to user's accuracies.

Table 31: User's (percent) and Producer's (percent) accuracy by number of FIA plots for tree-size class.

Tree-size Class	Number of Observed FIA Base-level Plots	Producer's Accuracy	Number of Mapped FIA Base-level Plots	User's Accuracy
F-TS1	46	37.0	54	44.4
F-TS2	148	66.2	173	56.6
F-TS3	69	23.2	47	34.0
W-TS1	9	66.7	9	66.7
W-TS2	17	41.2	16	43.8
W-TS3	11	9.1	3	33.3
NTS	108	94.4	106	96.2
Grand Total	**408**	**62.3**	**408**	**62.3**

Table 32 below shows the user's and producer's accuracy results, and number of FIA plots by detailed classes for canopy cover. Cover for this variable is recorded as *absolute* cover of plant species, which is the proportion of a plot's area included in the perpendicular downward projection of the species as an unobstructed view from above. Canopy cover classes are separated by tree (TC) and shrub (SC) cover classes. Tree classes include: TC1 from 10-29 percent cover, TC2 from 30-49 percent cover, TC3 from 50-59 percent cover, TC4 from 60-69 percent cover, and TC5 at 70 percent and greater cover. Shrub classes include: SC1 from 10-14 percent, SC2 from 15-24 percent, SC3 from 25-49 percent, SC4 at 50 percent or greater, and NCC for no cover class recorded.

The TC2 canopy cover class had the highest number of observed plots (112) while the TC1 class had the highest number of mapped plots (117). The next most common observed cover class was SC3 at 52 plots, followed by TC4 at 37 plots, and TC3 at 35 plots.

Excluding the NCC class, producer's accuracies were the highest for the SC3 class at 64 percent, followed by TC1 at 63 percent and SC1 at 50 percent; and the lowest for the TC5 at 11 percent, followed by SC2 at 12 percent. User's accuracies were somewhat similar to producer's accuracies.

Table 32: User's (percent) and Producer's (percent) accuracy by number of FIA plots for canopy cover class.

Canopy Cover Class	Number of Observed FIA Base-level Plots	Producer's Accuracy	Number of Mapped FIA Base-level Plots	User's Accuracy
TC1	107	62.6	117	57.3
TC2	112	33.9	88	43.2
TC3	35	34.3	55	21.8
TC4	37	18.9	25	28.0
TC5	9	11.1	17	5.9
SC1	6	50.0	10	30.0
SC2	17	11.8	13	15.4
SC3	52	63.5	53	62.3
SC4	7	28.6	8	25.0
NCC	26	73.1	22	86.4
Grand Total	408	45.1	408	45.1

Error Matrices Confusion Results

Table 33 through Table 35 show the error matrices results for the Caribou-Targhee mid-level map for vegetation type, tree-size class, and canopy cover class summaries.

Table 33 shows the error matrix results for vegetation type classes with the observed classes (rows) in order from the most common map unit to least common. Douglas-fir, mountain big sagebrush, and lodgepole pine are the most common observed and mapped classes, and together make up 41 and 53 percent, respectively, of the total observed and mapped plots. All three had producer’s accuracies above 71 percent and user’s accuracies above 52 percent.

Conifer mix (38 plots) and spruce/fir (28 plots) are the next most common observed map units with relatively low producer/user accuracies of 34/46 percent and 25/37 percent, respectively. The conifer mix class shows considerable confusion (usually below 40 percent accuracy) with the Douglas-fir, lodgepole pine, and spruce/fir classes; and the spruce/fir class shows considerable confusion with the Douglas-fir, lodgepole pine, and conifer mix classes.

Aspen is the next most common class with 23 observed plots and a relatively high producer’s/user’s accuracy of 74/55 percent. As mentioned earlier, conifer/aspen (22 plots) had the lowest producer’s accuracy and shows significant confusion with aspen and “other” conifer map units, while aspen/conifer (15 plots) shows significant confusion with aspen, Douglas-fir, and conifer/aspen.

Douglas-fir/lodgepole pine (17 plots) showed significant producer's confusion with Douglas-fir and lodgepole pine, while forest/mountain shrublands (18 plots) showed significant confusion with mountain big sagebrush. Bigtooth maple mix (15 plots) had high producer's accuracy at 67 percent, while juniper mix (14 plots) showed considerable confusion with Douglas-fir and mountain mahogany mix.

The remaining 12 classes all have eight or less observed plots each, with a grand total of only 52 plots. Although very small classes, the dwarf sagebrush (3 plots), ruderal grasslands (2 plots), and water (2 plots) classes had producer's accuracies of 100 percent. The barren/sparse vegetation class (8 plots) had high producer's accuracy at 75 percent, followed by alpine vegetation (5 plots) and dry big sagebrush mix (5 plots) at 60 percent producer's accuracies. The last six classes (mountain mahogany mix, limber pine/Douglas-fir, riparian herbaceous, subalpine herbaceous, montane herbaceous, whitebark pine mix) all have producer's accuracies of 50 percent or less.

Table 33: Error matrix with user's and producer's (percent) accuracies for observed and mapped vegetation type classes on the Caribou-Targhee.

Observed Vegetation Type Classes \ Mapped Vegetation Type Classes	Douglas-fir	Mountain Big Sagebrush	Lodgepole Pine	Conifer Mix	Spruce/Fir	Aspen	Conifer/Aspen	Forest/Mountain Shrublands	Douglas-fir/Lodgepole Pine	Aspen/Conifer	Bigtooth Maple mix	Juniper mix	Barren/Sparse Vegetation	Mountain Mahagony Mix	Limber Pine/Douglas-fir	Alpine Vegetation	Dry Big Sagebrush Mix	Montane Herbaceous	Whitebark Pine mix	Dwarf Sagebrush	Subalpine Herbaceous	Riparian Herbaceous	Ruderal Grasslands	Water	Grand Total	Producer's Accuracy
Douglas-fir	44		3	5			4		2	3															61	72
Mountain Big Sagebrush		49						5								1		1							56	88
Lodgepole Pine	2		42	1	1		1		2																49	86
Conifer Mix	9		7	13	6		2											1							38	34
Spruce/Fir	6		3	6	7		1			1	1				1				2						28	25
Aspen	1					17	1	1		2	1														23	74
Conifer/Aspen	6		7	1		4	2		1		1														22	9
Forest /Mountain Shrublands		8		1		1		6			1						1								18	33
Douglas-fir/Lodgepole Pine	5		6	2			2		2																17	12
Aspen/Conifer	3		1			5	3	1		2															15	13
Bigtooth Maple mix	2					1	1			1	10														15	67
Juniper mix	4					1	1				1	4		3											14	29
Barren/Sparse Vegetation													6								1		1		8	75
Mountain Mahagony Mix		1				1				2				4											8	50
Limber Pine/Douglas-fir	1				1									1	3										6	50
Alpine Vegetation						1								1		3									5	60
Dry Big Sagebrush Mix		2															3								5	60
Montane Herbaceous		3																1							4	25
Whitebark Pine mix					3														1						4	25
Dwarf Sagebrush																				3					3	100
Subalpine Herbaceous		1			1																1				3	33
Riparian Herbaceous																		1				1			2	50
Ruderal Grasslands																							2		2	100
Water																								2	2	100
Grand Total	83	64	69	29	19	31	18	13	7	11	15	4	6	9	4	4	4	4	3	3	2	1	3	2	408	56
User's Accuracy	53	77	61	45	37	55	11	46	29	18	67	100	100	44	75	75	75	25	33	100	50	100	67	100	56	

Table 34 shows the error matrix results for tree-size classes with the observed classes (rows) in order from most common tree-size class to least common. The F-TS2 class was the most commonly observed and mapped tree-size class with 148 and 173 plots, respectively. The producer's/user's accuracy for F-TS2 was relatively high at 66/57 percent, with comparable confusion between both the F-TS1 and F-TS3 classes. The NTS (108 plots) was the next most common observed class with a producer's accuracy of 94 percent. The F-TS3 (69 plots) and the F-TS1 (46 plots) both had relatively low producer's accuracies with considerable confusion with the F-TS2 class.

The W-TS1 (9 plots) was the least common observed class, and had a relatively high producer's accuracy of 67 percent, followed by the W-TS3 class (11 plots), which had the lowest producer's accuracy at nine percent, and considerable confusion with the F-TS2 and W-TS2 classes. The W-TS2 class (17 plots) had relatively low producer's accuracy at 41 percent, and confusion with almost all other classes. Producer's and user's accuracies were fairly similar for all tree-size classes.

Table 34: Error matrix with user's and producer's (percent) accuracies for observed and mapped tree-size classes on the Caribou-Targhee.

Observed Tree-size Classes	Mapped Tree-size Classes F-TS2	NTS	F-TS3	F-TS1	W-TS2	W-TS3	W-TS1	Grand Total	Producer's Accuracy
F-TS2	98		26	22	1		1	**148**	**66**
NTS	3	102		1	1		1	**108**	**94**
F-TS3	48		16	3	1		1	**69**	**23**
F-TS1	17	3	2	24				**46**	**37**
W-TS2	3	1	2	2	7	2		**17**	**41**
W-TS3	4		1	1	4	1		**11**	**9**
W-TS1				1	2		6	**9**	**67**
Grand Total	**173**	**106**	**47**	**54**	**16**	**3**	**9**	**408**	**62**
User's Accuracy	**57**	**96**	**34**	**44**	**44**	**33**	**67**	**62**	

Table 35 shows the error matrix results for canopy cover classes with the observed classes (rows) in order from most common canopy cover class to least common. The TC2 class was the most common observed class (112 plots), while the TC1 was the most common mapped class (117 plots). The TC2 class had relatively low producer/user's accuracies at 34/43 percent, respectively, with significant confusion with the TC1, TC3, and TC4 classes, The TC1 class had relatively high producer's accuracy at 63 percent with the majority of its confusion with the TC2 class and some confusion with the TC3 class.

The SC3 class (52 plots) was the next most common observed class with relatively high producer's/user's accuracies of 63/62 percent. Most of its confusion was with the other SC classes. The TC4 (37 plots) and TC3 (35 plots) classes both had relatively low producer's and user's accuracies. Producer's accuracies showed that the TC4 class was mainly confused with the TC2, TC3, and TC1 classes, while the TC3 class was mainly confused with the TC2, TC1, and TC4 classes. The NCC class (26 plots) had relatively high producer's (73 percent) and user's (86 percent) accuracies, while the SC2 class had low producer's accuracy (12 percent) with most of its confusion with the SC3 and SC1 classes.

The last three canopy cover classes (TC5, SC4, and SC1) all had less than ten observed plots each, with relatively low producer's accuracies of 50 percent or less.

Table 35: Error matrix with user's and producer's (percent) accuracies for observed and mapped canopy cover classes on the Caribou-Targhee.

Observed Canopy Cover Classes	Mapped Canopy Cover Classes TC2	TC1	SC3	TC4	TC3	NCC	SC2	TC5	SC4	SC1	Grand Total	Producer's Accuracy
TC2	38	34	1	10	20			8	1		112	34
TC1	23	67		3	9	1		3	1		107	63
SC3			33		1	1	10		3	4	52	63
TC4	14	4		7	10			2			37	19
TC3	9	7		4	12			3			35	34
NCC		3	3			19	1				26	73
SC2		2	8			1	2		1	3	17	12
TC5	4			1	3			1			9	11
SC4			5						2		7	29
SC1			3							3	6	50
Grand Total	**88**	**117**	**53**	**25**	**55**	**22**	**13**	**17**	**8**	**10**	**408**	**45**
User's Accuracy	**43**	**57**	**62**	**28**	**22**	**86**	**15**	**6**	**25**	**30**	**45**	

Discussion of Re-Classification Results (FIA Base-Level)

In general, the re-classification resulted in better accuracies than the initial intersection of plot/condition level data that did not consider the spatial relationships between FIA data, the mapped polygons, and the imagery. It should also be noted that there was significant time required to complete the re-classification.

Discussion of Overall Results

Due to the unbiased, spatially balanced, extensive natures of the FIA systematic grid, the FIA base-level plots are perhaps best suited for addressing overall accuracies. Whether considering vegetation group, vegetation type, tree-size, or canopy cover. Generally the most common classes are adequately and spatially represented by the FIA base-level grid. On the other hand, accuracies for uncommon (one to ten percent) classes are usually better addressed by supplementing the FIA base-level plots, to achieve the desired number of plot samples for each class. The following discussions refer to Table 28, which showed summaries of the overall re-classification accuracies for the Caribou-Targhee.

Vegetation Group Overall

Although perhaps not as important for detailed analysis, map group is the first coarse filter for determining major map classes. Here, it is important to have reference data with an appropriate mix of scale and detail to adequately distinguish map group. Since map group is the broadest-level of classification for vegetation types and dominance types, it generally has the best accuracy (83 percent), although confusion at this level will propagate to finer-level classifications.

Vegetation Type Overall

Considering there are 27 vegetation types mapped on the Caribou-Targhee, an overall accuracy of 56 percent is not unusual. For example, a similar extensive predictive mapping effort for forest type group (14 classes) and subgroup (21 classes) in all the interior west states using FIA plot data resulted in overall accuracies of 64 and 57 percent, respectively (Blackard and Moisen 2005).

Tree-size Overall

There were seven classes for tree-size including forest, woodland, and non-tree on the Caribou-Targhee with an overall accuracy of 62 percent. Although this may seem low, tree-size is typically not mapped as well as vegetation types, due to difficulties in modeling tree-size using remotely sensed spectral imagery.

Canopy Cover Overall

There were ten canopy cover classes including trees, shrubs, and non-cover classes on the Caribou-Targhee with an overall accuracy of 45 percent. Tree canopy cover on FIA plots is based on four 100-foot transects for tree cover thresholds above ten percent, and on one acre surrounding subplot center for tree cover considered at or below ten percent. Live tree canopy cover is recorded to the nearest percent. Cover estimates for shrubs, forbs, and graminoids are based on ocular estimates within the 1/24th acre subplots, and are recorded by species for all species with three percent or greater cover and by lifeform down to 1 percent.

Subset Summary Types Overall

Table 28 also shows results for several summary type subsets of the re-classified data, which do not include all of the FIA plots. If only tree map unit classes (300 plots) are included, then the overall tree-size producer's accuracy decreases to 51 percent. This is mainly due to eliminating the lack of tree-size calls on fairly obvious nonforest plots (102). If only map units that are assigned cover (382 plots) are included, then the overall producer's accuracy decreases to 43 percent. Another summary subset is for observed plots with only tree-cover (300 plots) recorded where producer's accuracy decreased to 42 percent. If the remaining plots with recorded cover (82 plots) are included, then the user's accuracy increases to 49 percent. This would be for the shrub cover class plots, which had moderately better accuracies than the tree cover plots.

Discussion of Error Matrices Confusion Results

Vegetation Group Confusion

Table 27 showed that the shrubland (82 plots) and the conifer forest (203 plots) map groups had the least confusion with other observed map groups. Shrubland was the most mappable group in terms of producer's accuracy and had negligible confusion with other map groups. Most of the conifer forest confusion was with the deciduous forest map group (14 plots), of which ten plots were in the conifer/aspen map unit. Since conifer/aspen map unit was labeled as a deciduous forest group this gives the appearance of a map group disparity instead of map unit disparity.

Deciduous forest (60 plots) was the next most common observed map group, which appears to have significant confusion with conifer forest (20 plots). However, 15 of those 20 observed plots were conifer/aspen map unit (deciduous map group). Again, this gives the appearance of a map group disparity instead of map unit disparity. If conifer/aspen were considered as conifer map group the deciduous forest producer's accuracy would increase from 60 to 80 percent, the conifer forest producer's accuracy would increase from 92 to 97 percent, and the overall map group producer's accuracy would increase from 82 to 88 percent.

Woodland (37 plots) was the next most common observed map group with a producer's accuracy of 60 percent. Most of its confusion was with the deciduous (8 plots) and conifer (6 plots) forest map groups. However, six of the eight deciduous-confused plots were woodland mixes with conifer forest species indicated as the primary species (e.g. PSME-CELE3, POTR5-JUNIP, PSME-JUSC2). Also, five of the six conifer-confused plots were woodland mixes, with conifer forest species indicated as the primary species (PSME-ACGR, PSME-JUSC2). If these 11 plots were considered as conifer map group, the woodland producer's accuracy would increase from 60 to 85 percent and the conifer forest producer's accuracy would increase from 92 to 89 percent.

Non Vegetated (10 plots) was the next most common observed map group with a high producer's accuracy of 80 percent, followed by herbaceous (9 plots) with a low producer's accuracy of 44 percent. Most of the herbaceous confusion was with the shrubland (4 plots) map group. The last two map groups were alpine vegetation, with five observed plots, and riparian with two observed plots. These groups had producer's accuracies of 60 and 50 percent, respectively.

In general, map group accuracies were highest for the most common types, and lower for the less common types. In addition, map group accuracies would be higher if the map groups were always reflective of the most dominant cover species in the map unit (e.g., conifer/aspen as conifer forest instead of deciduous forest map group). This is important to remember if using map groups as a coarse filter for analysis purposes, since it may be desired to filter at a finer level (map unit or dominance type) depending on the management question to be answered.

Vegetation Type Confusion

Table 33 shows that usually forest map units that are pure (>80 percent cover of one species) have the best producer's accuracies (>70 percent), such as lodgepole pine, aspen, and Douglas-fir. These map units are also some of the most common types in terms of the area mapped and the number of sampled FIA plots. Almost all of the lodgepole pine or Douglas-fir confusion was with other coniferous map units. Most of the pure aspen confusion was with other deciduous forest or deciduous nonforest map units.

Of the larger map units, mountain big sagebrush (56 plot/conditions) had the best producer's accuracy (88 percent) with almost all of its confusion with forest and mountain shrubland, the next largest nonforest map unit. Likewise, forest and mountain shrubland had most of its confusion with mountain big sagebrush.

Conifer mix was the largest forest "non-pure" map unit with almost all of its user's and producer's confusion with other coniferous map units. As with the other forest non-pure (mix) map units, all of the confusion was with other forest mixes or pure forest map units.

These include map units spruce/fir, Douglas-fir/lodgepole, limber pine/Douglas-fir, and Whitebark mix.

Aspen/conifer had most of its confusion with aspen and conifer/aspen. Conifer/aspen had most of its confusion with other conifers and aspen.

The bigtooth maple mix map unit had relatively good producer's accuracy with most of its confusion with other deciduous forest map units. The juniper mix had most of its confusion with Douglas-fir and mountain mahogany mix, where it commonly co-occurs.

The remaining map units all had less than ten FIA plots observed or mapped. Interpretations or insights into error results for these are potentially misguided, even though some may have fairly good user's or producer's accuracies.

Tree-size Confusion

Table 34 shows that for forest and woodland map units, the F-TS2 tree-size class had the most mapped and observed plots. For most populations this would be an expected tree-size distribution. Almost all of the confusion for this tree-size map unit was with the neighboring classes (F-TS1 and F-TS3). Likewise, the F-TS1 and F-TS3 had most of their confusion with the bordering F-TS2 tree-size class. Other than NTS, the remaining tree-size map units had too few observations to evaluate.

Canopy Cover Confusion

Table 35 shows that the most commonly observed map unit for canopy cover (TC2) had most of its confusion with the neighboring classes (F-TS1 and F-TS3). The TC1 class had good producer's accuracy with most of its confusion, as expected, with the TC2 and TC3 classes, respectively. This class does not have a lower class with which to introduce confusion. The TC3 class had most of its confusion with the TC2 and TC1 classes, respectively, and the TC4 class had most of its confusion with the TC2 and TC3 classes, respectively.

The SC3 map unit had good producer's accuracy with most of its confusion with the SC2 and SC1 classes, respectively. Other than NCC, the remaining canopy cover map units had too few observations to evaluate.

Conclusions for Accuracy Assessment

Since its inception in the early 1980s, thematic accuracy assessment of remote sensing data has consistently been a particularly challenging portion of the mapping process. Despite its critical importance, there are a wide variety of data types and methods that can be used to attain relatively similar goals. Although a number of definitive standards have been adopted throughout the remote sensing community over the years, there still remains a great degree of uncertainty to the question of how best to perform a reliable, repeatable, and realistic accuracy assessment.

Although optimum reference datasets for accuracy assessment would be designed specifically for use with the final map product, this is often very cost prohibitive and time-consuming. The use of inventory data, such as FIA, involves trade-offs between resolution and reliability. FIA data provide a statistically robust, spatially distributed, unbiased sample that is readily available as a source of information that can serve as a base-level accuracy assessment for mid-level mapping. When used for accuracy assessments, consideration should be given to address differences in data collection methods compared with the map products, such as the re-classification completed for this assessment.

Table 36 below shows the progression of accuracy assessments for the Caribou-Targhee mid-level map. In general, four assessments of mapped attribute information were performed using various sets of the FIA plot data:

1. The first assessment was performed primarily for area estimation comparisons at the plot/condition level (433 plot/conditions) using only the FIA data directly for classification, it was intersected with the map for initial results.
2. The second assessment was performed by intersecting the same classified FIA data only at the plot level using only condition 1 (382 plots).
3. The third assessment (re-classification) was purposely designed for site specific accuracy assessment using FIA as a reference dataset along with the mapped polygons. This was done only at the plot level (408 plots), involved an exhaustive comparison and evaluation of FIA plots with the mapped polygons, and is the assessment presented in this report.

The fourth assessment was a subset (256 plots) of the third assessment using only "FIA plot data evaluation type code 1" FIA plots (

Table 16).

Table 36: Overall accuracies by number of FIA plot/conditions and mapped attributes for four alternative site-specific accuracy assessments, Caribou-Targhee.

Overall Accuracies by Evaluation Type					
Alternative Site-specific Accuracy Assessment	**Number of FIAplots/conditions**	**Vegetation Map Group**	**Vegetation Map Unit**	**Tree-size**	**Crown cover**
All Plot/Conditions	433	73%	48%	55%	38%
All Center Plot Conditions (condid 1)	382	77%	50%	60%	42%
All Plot Re-classification	408	83%	56%	62%	45%
Re-classified Evaluation Type 1	256	85%	61%	66%	47%

Table 36 shows an improvement in accuracies for all mapped attributes for each successive assessment. Not surprisingly, the first assessment has the lowest accuracies, as it was most suited for area estimates and not evaluated along with the mapped polygons. The second assessment probably has better accuracies only because it potentially eliminates any second condition (51 plot/conditions) that could be located further from plot center, and potentially outside the mapped polygon. As expected, the third assessment (re-classification) has even better accuracies since it was evaluated against the mapped polygons and considered differences between the plot data and the mapped product.

Finally, the fourth assessment uses only the FIA plots (257 plots) that were coded as "using the FIA data directly" for re-classification purposes. Briefly, this means that the plot was considered to be representative enough of its associated mapped polygon to use the FIA data directly without any photo-interpretation or other evaluation processes (Figure 9). This assessment may be closer to using an accuracy assessment design specifically tailored to assessing the mapped polygons. Although this assessment violates the unbiased nature of any grid inventory, it may show the real potential of the map accuracies. The assessment may also reflect the potential improvements of incorporating subsequent intensified, stratified, or other reference datasets with the FIA base-line data to increase the number of accuracy assessment sample plots.

Another way to improve accuracies is by sacrificing thematic detail. Depending on the management question that needs answering, any of the error matrices presented may be merged accordingly to potentially improve accuracy for a new thematic class. Table 37shows the error matrix results for vegetation type class (previous Table 33) collapsed for aspen as either the most or second most abundant forest species combined with another conifer. This combines the previous vegetation types (aspen, conifer/aspen, and aspen/conifer). The improved user's and producer's accuracies for this merged class are now 60 percent.

Table 37: Error matrix for observed and mapped vegetation type classes on the Caribou-Targhee with collapsed aspen units.

Observed Vegetation Type Classes	Douglas-fir	Mountain Big Sagebrush	Lodgepole Pine	Conifer Mix	Spruce/Fir	Aspen-Conifer/Aspen-Aspen/Conifer	Forest & Mountain Shrublands	Douglas-fir/Lodgepole	Bigtooth Maple mix	Juniper mix	Barren/Sparsely Vegetated	Mountain Mahagony Mix	Limber Pine/Douglas-fir	Alpine Herbaceous	Wyoming, Basin, & Bonneville Sagebrush	Montane Herbaceous	Whitebark mix	Dwarf Sagebrush	Subalpine Herbaceous	Riparian Herbaceous	Ruderal Grasslands	Water	GrandTotal	Producer's Accuracy
	Mapped Vegetation Type Classes																							
Douglas-fir	44		3	5		7		2															**61**	**72**
Mountain Big Sagebrush		49					5							1		1							**56**	**88**
Lodgepole Pine	2		42	1	1	1		2															**49**	**86**
Conifer Mix	9		7	13	6	2										1							**38**	**34**
Spruce/Fir	6		3	5	7	2			1				1				2						**28**	**25**
Aspen-Conifer/Aspen-Aspen/Conifer	10		8	1		36	2	1	2														60	**60**
Forest /Mountain Shrublands		8		1		1	6		1						1								**18**	**33**
Douglas-fir/Lodgepole Pine	5		6	2		2		2															**17**	**12**
Bigtooth Maple mix	2					3			10														**15**	**67**
Juniper mix	4					2			1	4		3											**14**	**29**
Barren/Sparse Vegetation											6								1		1		**8**	**75**
Mountain Mahagony Mix		1				3						4											**8**	**50**
Limber Pine/Douglas-fir	1				1							1	3										**6**	**50**
Alpine Vegetation						1						1		3									**5**	**60**
Dry Big Sagebrush Mix		2													3								**5**	**60**
Montane Herbaceous		3														1							**4**	**25**
Whitebark Pine mix					3												1						**4**	**25**
Dwarf Sagebrush																		3					**3**	**100**
Subalpine Herbaceous		1			1														1				**3**	**33**
Riparian Herbaceous																1				1			**2**	**50**
Ruderal Grasslands																					2		**2**	**100**
Water																						2	**2**	**100**
Grand Total	**84**	**64**	**69**	**28**	**19**	60	**13**	**7**	**15**	**4**	**6**	**9**	**4**	**4**	**4**	**4**	**3**	**3**	**2**	**1**	**3**	**2**	**408**	**56**
User's Accuracy	**54**	**77**	**61**	**46**	**37**	60	**46**	**29**	**67**	**100**	**100**	**44**	**75**	**75**	**75**	**25**	**33**	**100**	**50**	**100**	**67**	**100**	**56**	

Data Management

Final Polygon Layer Locations

(Enterprise Data Center/Spatial Data Engine)

The existing vegetation 'unioned' polygon feature class and Federal Geographic Data Committee (FGDC)-compliant metadata are stored and maintained in ESRI geodatabase format within individual forest ArcSDE (Spatial Database Engine) schemas at the Forest Service Enterprise Data Center. This feature class serves as the authoritative source data. It is recommended that the data be accessed by Forest Service users through Citrix using ESRI ArcGIS software applications (https://apps.fs.usda.gov/Citrix/auth/login.aspx) to optimize performance. ArcGIS layer files (*.lyr) containing polygon feature symbology for vegetation type, canopy cover, and tree size can be accessed from ArcGIS applications through Citrix at T:\FS\Reference\GIS\r04\LayerFile\CTF. More information on procedures for accessing geospatial data through Citrix at the Data Center can be found at http://fsweb.egis.fs.fed.us/EGIS_tools/GettingStartedEDC.shtml.

Ancillary and Intermediate Data

All other data related to the project, including ancillary and intermediate geospatial data, reference site information, and supporting documentation are stored and archived as the trusted source data set on the Intermountain Region Office local Network Attached Storage (NAS) device and tape backup system. Assistance in accessing the authoritative source data through Citrix or obtaining a copy of ancillary and intermediate data sets can be facilitated by Regional Information Management project partners.

Conclusion

The status and condition of existing vegetation on the Caribou-Targhee NF is a critical factor for many of its land-management decisions. This document provides an overview of the methods, products, and results of existing vegetation classification, mapping, and quantitative inventory to characterize the existing vegetation on the forest. When used in conjunction with the associated maps, taxonomic keys, and data, this document provides the foundation for supporting applicable land management decisions using the best-available science. Since these products reflect a single point in time, specifically 2010/2011 conditions, land managers should develop a strategy for maintaining their initial investment into the future. Updated maintenance and future updates keep the vegetation map current and useful as vegetation disturbances, treatments, or gradual change occur over time.

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List of Figures and Tables

Figures

Tables

Appendices

Appendix I: Vegetation Indices and Topographic Derivatives

Vegetation indices and topographic derivatives used in the mapping process.

Geospatial Data	**Source**	**Use**
Landsat TM – spring NDVI	Erdas model	Modeling
Landsat TM – summer NDVI	Erdas model	Modeling & Segmentation
Landsat TM – fall NDVI	Erdas model	Modeling
Landsat TM – spring Tasseled Cap	Erdas model	Modeling
Landsat TM – summer Tasseled Cap	Erdas model	Modeling
Landsat TM – fall Tasseled Cap	Erdas model	Modeling
Landsat TM – spring Principal Component	Erdas model	Modeling
Landsat TM – summer Principal Component	Erdas model	Modeling
Landsat TM – fall Principal Component	Erdas model	Modeling
NAIP (1.0-meter) - NDVI	Customized model	Modeling & Segmentation
Resource photography (0.5 meter) NDVI	Customized model	Modeling
Slope (degree & thematic)	Customized model	Modeling
Aspect (cosine & thematic)	Customized model	Modeling
Curvature	Customized model	Modeling
Heatload	Customized model	Modeling
Fully illuminated hillshade	Customized model	Segmentation
Valley bottom	Customized model	Segmentation
Vegetation Change Tracker (VCT)	Customized model	Modeling

Appendix II: Partnerships and Participants

Caribou-Targhee NF Partners:

• Robert Mickelsen	Ecosystem Branch Chief
• Rose Lehman	Botanist
• Heidi Heyrend	Rangeland Management Specialist
• Tom Silvey	Supervisory Forester
• Martha Mousel	GIS Coordinator
• Klara Varga	Botanist, Biological Science Technician

Caribou-Targhee Draft Map Review Participants:

• Connie Alfieri	Forestry Technician
• Mike Alfieri	Forestry Technician
• Cheryl Beck	Cartographic Technician
• Wayne Beck	Silviculturist
• Hans Bastian	Rangeland Management Specialist
• Chris Colt	Wildlife Biologist
• Bill Davis	Natural Resource Specialist
• Elizabeth Davy	District Ranger
• Dennis Duehren	Montpelier District Ranger
• Devon Green	Wildlife Biologist
• Kara Green	Soil Scientist
• Tammy Fletcher	Forest Wildlife Biologist
• Greg Hanson	Rangeland Management Specialist
• Cathey Hardin	Supervisory Forester
• Mathew Hoggan	Range Specialist
• Cody Kidd	Engine Foreman (Fire)
• Shane Jacobson	Supervisory National Resource Specialist
• Arik Jorgensen	FMO (Fuels)
• Robert Mickelsen	Ecosystem Branch Chief
• Klara Varga	Botanist, Biological Science Technician
• Kyle Moore	Rangeland Management Specialist
• Becky Nedrow	Forester

- Garth Nelson Rangeland Management Specialist
- Kevin Parker Rangeland Management Specialist
- Richard Roberson Supervisory Natural Resource Specialist
- Jim Robertson Natural Resource Specialist
- Jane Rushane Rangeland Management Specialist

Intermountain Regional Office Partners:

- David Tart Regional Ecologist
- Don Fallon Regional Resource Inventory and Monitoring Coordinator
- Sanford Moss Regional Remote Sensing Coordinator
- Larry DeBlander Regional Vegetation Analyst

Remote Sensing Application Center Partners:

- Kevin Megown Resource Mapping, Inventory, and Monitoring Program Leader
- Paul Maus Resource Mapping, Inventory, and Monitoring Contract Leader
- Wendy Goetz Vegetation Mapping Group Leader, Remote Sensing Specialist
- Gabe Bellante Remote Sensing Specialist
- Steven Dale Remote Sensing Specialist
- Peter Gamberg Remote Sensing Specialist
- Carson Stam Remote Sensing Specialist
- Mark Beaty Remote Sensing Specialist

Interior West Forest Inventory and Analysis Partners:

- Michael Wilson Inventory and Monitoring Program Manager
- Bob Rhoads Inventory and Monitoring Team Leader / Supervisory Forester
- Mark Rubey Computer Programmer Analyst
- Brian Lanier Information Technology Specialist
- Tracey Frescino Forester
- Val Nelson Ecologist
- Brian Bialach Forester

- Mark Fleck Forestry Technician
- Tristan Kelley Forester
- Mike Haldeman Ecologist

Northern Regional Office - USFS

- Renate Bush Inventory and Analysis, Program Manager

Appendix III: Existing Vegetation Keys

Caribou-Targhee Existing Vegetation Keys

9/25/2013 RML, DLT

NOTE: These keys apply only to existing vegetation, not potential or historical vegetation.

R4 Key to Vegetation Formations

03/28/2008

This key does not apply to lands used for agriculture or urban/residential development. It applies only to natural and semi-natural vegetation dominated by vascular plants. Semi-natural vegetation includes planted vegetation that is not actively managed or cultivated. All cover values in *this key to formations* are absolute cover, not relative cover, for the life form. See Appendix A for a discussion of absolute versus relative cover. In this key tree cover includes both regeneration and overstory sized trees, so that young stands of trees are classified as forest.

			Key or D.T.	Map Unit
1a		All vascular plants total < 1% canopy cover……………………………………....	**Non-Vegetated (p20)**	**BR/SV**
1b		All vascular plants total ≥ 1% canopy cover……………………………………....	2	
	2a	All vascular plants total < 10% canopy cover………………………………………	**Sparse Veg. BR/SV**	**BR/SV**
	2b	All vascular plants total ≥ 10% canopy cover………………………………………	3	
3a		Trees total ≥ 10% canopy cover…………………………………………………...	4	
3b		Trees total < 10% canopy cover…………………………………………………...	5	
	4a	Stand located above continuous forest line and trees stunted (< 5m tall) by harsh alpine growing conditions…………………………………………………...	**Shrubland Key (p.9)**	
	4b	Stand not above continuous forest line; trees not stunted………………………...	**Forest & Woodland Key (p.2)**	
5a		Shrubs total ≥ 10% canopy cover…………………………………………………	**Shrubland Key (p.9)**	
5b		Shrubs total < 10% canopy cover…………………………………………………	6	
	6a	Herbaceous vascular plants total ≥ 10% canopy cover……………………………	7	
	6b	Herbaceous vascular plants total < 10% canopy cover……………………………	8	
7a		Total cover of graminoids ≥ total cover of forbs……………………………………	**Grassland Key (p.12)**	
7b		Total cover of graminoids < total cover of forbs……………………………………	**Forbland Key (p.17)**	
	8a	Trees total ≥ 5% canopy cover………………………………………………….....	**Sparse Tree**	**BR/SV**
	8b	Trees total < 5% canopy cover………………………………………………….....	9	
9a		Shrubs total ≥ 5% canopy cover…………………………………………………..	**Sparse Shrub BR/SV**	**BR/SV**
9b		Shrubs total < 5% canopy cover…………………………………………………..	10	
	10a	Herbaceous vascular plants total ≥ 5% canopy cover……………………………..	**Sparse Herb BR/SV**	**BR/SV**
	10b	Herbaceous vascular plants total < 5% canopy cover……………………………..	**Sparse Veg. BR/SV**	**BR/SV**

Key to Forest and Woodland Dominance Types and DT Phases

2/5/2013 RML, DLT

Instructions:

1. Preferably, plots or polygons should be keyed out based on overstory canopy cover (trees forming the upper or uppermost canopy layer) by tree species.
2. Plots or polygons lacking such data or lacking an overstory layer should be keyed out using total cover by species.
3. If a plot or polygon does not key out using overstory cover, then it may be keyed using total tree cover.
4. If two trees are equally abundant, the species encountered first in the key is recorded as the most abundant.

			DT or DT Phase Code	Veg Type Map Unit	Veg Grp
1a		Narrowleaf cottonwood is the most abundant tree species……..	**POAN3 d.t.**	**RSH**	**R**
1b		Narrowleaf cottonwood not the most abundant tree species……	**2**		
	2a	Boxelder is the most abundant tree species……………………….	**ACNE2 d.t.**	**RSH**	**R**
	2b	Boxelder is not the most abundant tree species…………………..	**3**		
3a		Thinleaf alder is the most abundant tree/shrub species…………	**ALINT d.t.**	**RSH**	**R**
3b		Thinleaf alder is not the most abundant tree/shrub species…….	**4**		
	4a	Water birch is the most abundant tree/shrub species……………	**BEOC2 d.t.**	**RSH**	**R**
	4b	Water birch is not the most abundant tree/shrub species……….	**4.5**		
4.5a		Russian olive is the most abundant tree/shrub species…………..	**ELAN d.t**	**RSH**	**R**
4.5b		Russian olive is not the most abundant tree/shrub species………	**5**		
5a		Blue spruce is the most abundant tree species…………………..	**PIPU d.t.**	**SF**	**C**
5b		Blue spruce is not the most abundant tree species………………	**6**		
	6a	Quaking aspen is the most abundant tree species……………......	**7**		
	6b	Quaking aspen is not the most abundant tree species…………..	**12**		
7a		Quaking aspen ≥ 80% relative canopy cover……………………..	**POTR5-POTR5 d.t.p.**	**AS**	**D**
7b		Quaking aspen < 80% relative canopy cover……………………..	**8**		
	8a	Lodgepole pine is the second most abundant tree species; it and aspen total ≥ 65% relative canopy cover……………………..	**POTR5-PICO d.t.p.**	**AS/C**	**D**
	8b	Lodgepole pine not the second most abundant tree species and/or it			

		DT or DT Phase Code	Veg Type Map Unit	Veg Grp
	and aspen total < 65% relative canopy cover…………..	**9**		
9a	Douglas-fir is the second most abundant tree species; it and aspen total ≥ 65% relative canopy cover…………………………...	**POTR5-PSME d.t.p.**	**AS/C**	**D**
9b	Douglas-fir is not the second most abundant tree species and/or it and aspen total < 65% relative canopy cover…….....................	**10**		
10a	Subalpine fir is the second most abundant tree species; it and aspen total ≥ 65% relative canopy cover…………………………	**POTR5-ABLA d.t.p.**	**AS/C**	**D**
10b	Subalpine fir is not the second most abundant tree species and/or it and aspen total < 65% relative canopy cover……..........	**11**		
11a	Aspen plus bigtooth maple total ≥ 65% relative canopy cover…...	**POTR5-ACGR3 d.t.p.**	**MPmix**	**W**
11b	Aspen plus bigtooth maple total < 65% relative canopy cover…...	**11.5**		
11.5a	Aspen plus Rocky Mountain juniper, and/or Utah juniper total ≥ 65% relative canopy cover…………………….......................	**POTR5-JUNIP d.t.p.**	**Jmix**	**W**
11.5b	Aspen plus Rocky Mountain juniper, and Utah juniper total < 65% relative canopy cover……..	**Other POTR5 d.t**	**AS**	**D**
12a	Whitebark pine is the most abundant tree species…………….......	**13**		
12b	Whitebark pine is not the most abundant tree species………….	**16**		
13a	Whitebark pine ≥ 80% relative canopy cover……………………..	**PIAL-PIAL d.t.p.**	**WBmix**	**C**
13b	Whitebark pine < 80% relative canopy cover…………..............	**14**		
14a	Engelmann spruce is the second most abundant tree species; it and whitebark pine total ≥ 65% relative canopy cover…………..	**PIAL-PIEN d.t.p.**	**WBmix**	**C**
14b	Engelmann spruce not the second most abundant tree species and/or it and whitebark pine total < 65% relative canopy cover...	**15**		
15a	Subalpine fir is the second most abundant tree species; it and whitebark pine total ≥ 65% relative canopy cover………………..	**PIAL-ABLA d.t.p.**	**WBmix**	**C**
15b	Subalpine fir is not the second most abundant tree species and/or it and whitebark pine total < 65% relative canopy cover...	**Other PIAL d.t.**	**WBmix**	**C**
16a	Limber pine is the most abundant tree species………………	**17**		
16a	Limber pine is not the most abundant tree species…………..	**19**		
17a	Limber pine ≥ 80% relative canopy cover……………………..	**PIFL2-PIFL2 d.t.p.**	**LM/DF**	**C**
17b	Limber pine < 80% relative canopy cover…………..............	**18**		
18a	Douglas-fir is the second most abundant tree species; it and limber pine total ≥ 65% relative canopy cover…………………….	**PIFL2-PSME d.t.p.**	**LM/DF**	**C**

			DT or DT Phase Code	Veg Type Map Unit	Veg Grp
	18b	Douglas-fir is not the second most abundant tree species and/or it and limber pine total < 65% relative canopy cover…….	**Other PIFL2 d.t.**	**LM/DF**	**C**
19a		Ponderosa pine is the most abundant tree species………………	**PIPO d.t.**	**Cmix**	**C**
19b		Ponderosa pine is not the most abundant tree species…………	**19**		
	20a	Lodgepole pine is the most abundant tree species…………......	**21**		
	20b	Lodgepole pine is not the most abundant tree species…………	**26**		
21a		Lodgepole pine ≥ 80% relative canopy cover……………………..	**PICO-PICO d.t.p.**	**LP**	**C**
21b		Lodgepole pine < 80% relative canopy cover……………………..	**22**		
	22a	Aspen is the second most abundant tree species; it and lodgepole pine total ≥ 65% relative canopy cover………………..	**PICO-POTR5 d.t.p.**	**C/AS**	**D**
	22b	Aspen is not the second most abundant tree species and/or it and lodgepole pine total < 65% relative canopy cover………….	**23**		
23a		Douglas-fir is the second most abundant tree species; it and lodgepole pine total ≥ 65% relative canopy cover………………..	**PICO-PSME d.t.p.**	**DF/LP**	**C**
23b		Douglas-fir is not the second most abundant tree species and/or it and lodgepole pine total < 65% relative canopy cover...	**24**		
	24a	Engelmann spruce is the second most abundant tree species; it and lodgepole pine total ≥ 65% relative canopy cover………….	**PICO-PIEN d.t.p.**	**Cmix**	**C**
	24b	Engelmann spruce not the second most abundant tree species and/or it and lodgepole pine total < 65% relative canopy cover...	**25**		
25a		Subalpine fir is the second most abundant tree species; it and lodgepole pine total ≥ 65% relative canopy cover………………..	**PICO-ABLA d.t.p.**	**Cmix**	**C**
25b		Subalpine fir is not the second most abundant tree species and/or it and lodgepole pine total < 65% relative canopy cover...	**Other PICO d.t.**	**Cmix**	**C**
	26a	Douglas-fir is the most abundant tree species…………………......	**27**		
	26b	Douglas-fir is not the most abundant tree species………………	**36**		
27a		Douglas-fir ≥ 80% relative canopy cover………………………….	**PSME-PSME d.t.p.**	**DF**	**C**
27b		Douglas-fir < 80% relative canopy cover…………………………..	**28**		
	28a	Aspen is the second most abundant tree species: it and Douglas-fir total ≥ 65% relative canopy cover…………………….	**PSME-POTR5 d.t.p.**	**C/AS**	**D**
	28b	Aspen is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……................	**29**		
29a		Limber pine is the second most abundant tree species: it and Douglas-fir total ≥ 65% relative canopy cover…………………….	**PSME-PIFL2 d.t.p.**	**LM/DF**	**C**
29b		Limber pine is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……..	**30**		

			DT or DT Phase Code	Veg Type Map Unit	Veg Grp
	30a	Lodgepole pine is the second most abundant tree species, it and Douglas-fir total ≥ 65% relative canopy cover………………	**PSME-PICO d.t.p.**	**DF/LP**	**C**
	30b	Lodgepole pine is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……..	**31**		
31a		Engelmann spruce is the second most abundant tree species; it and Douglas-fir total ≥ 65% relative canopy cover………………	**PSME-PIEN d.t.p.**	**Cmix**	**C**
31b		Engelmann spruce not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover.........	**32**		
	32a	Subalpine fir is the second most abundant tree species; it and Douglas-fir total ≥ 65% relative canopy cover…………………….	**PSME-ABLA d.t.p.**	**Cmix**	**C**
	32b	Subalpine fir is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover.........	**33**		
33a		Curlleaf mountain mahogany is the second most abundant tree species; it and Douglas-fir total ≥ 65% relative canopy cover…..	**PSME-CELE3 d.t.p.**	**MMmix**	**W**
33b		Curlleaf mountain mahogany is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover..	**34**		
	34a	Rocky Mountain juniper is the second most abundant tree species; it and Douglas-fir total ≥ 65% relative canopy cover…..	**PSME-JUSC2 d.t.p.**	**Jmix**	**W**
	34b	Rocky Mountain juniper is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover..	**35**		
35a		Bigtooth maple is the second most abundant tree species; it and Douglas-fir total ≥ 65% relative canopy cover………………	**PSME-ACGR3 d.t.p.**	**MPmix**	**W**
35b		Bigtooth maple not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover.........	**Other PSME d.t.**	**Cmix**	**C**
	36a	Engelmann spruce is the most abundant tree species…………..	**37**		
	36b	Engelmann spruce is not the most abundant tree species………	**42**		
37a		Engelmann spruce ≥ 80% relative canopy cover…………………	**PIEN-PIEN d.t.p.**	**SF**	**C**
37b		Engelmann spruce < 80% relative canopy cover…………………	**38**		
	38a	Whitebark pine is the second most abundant tree species; it and Engelmann spruce total ≥ 65% relative canopy cover……..	**PIEN-PIAL d.t.p.**	**WBmix**	**C**
	38b	Whitebark pine is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover..	**39**		

			DT or DT Phase Code	Veg Type Map Unit	Veg Grp
39a		Lodgepole pine is the second most abundant tree species; it and Engelmann spruce total ≥ 65% relative canopy cover……...	**PIEN-PICO d.t.p.**	**Cmix**	**C**
39b		Lodgepole pine is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover..	**40**		
	40a	Douglas-fir is the second most abundant tree species; it and Engelmann spruce total ≥ 65% relative canopy cover……..........	**PIEN-PSME d.t.p.**	**Cmix**	**C**
	40b	Douglas-fir not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover..........	**41**		
41a		Subalpine fir is the second most abundant tree species; it and Engelmann spruce total ≥ 65% relative canopy cover……..........	**PIEN-ABLA d.t.p.**	**SF**	**C**
41b		Subalpine fir not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover.......	**Other PIEN d.t.**	**Cmix**	**C**
	42a	Subalpine fir is the most abundant tree species………………….	**43**		
	42b	Subalpine fir is not the most abundant tree species……………..	**49**		
43a		Subalpine fir ≥ 80% relative canopy cover………………………...	**ABLA-ABLA d.t.p.**	**SF**	**C**
43b		Subalpine fir < 80% relative canopy cover………………………...	**44**		
	44a	Aspen is the second most abundant tree species: it and Subalpine fir total ≥ 65% relative canopy cover…………………..	**ABLA-POTR5 d.t.p.**	**C/AS**	**D**
	44b	Aspen is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover…….............	**45**		
45a		Whitebark pine is the second most abundant tree species; it and subalpine fir total ≥ 65% relative canopy cover……...............	**ABLA-PIAL d.t.p.**	**WBmix**	**C**
45b		Whitebark pine is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover.......	**46**		
	46a	Lodgepole pine is the second most abundant tree species; it and subalpine fir total ≥ 65% relative canopy cover……...............	**ABLA-PICO d.t.p.**	**Cmix**	**C**
	46b	Lodgepole pine is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover.......	**47**		
47a		Douglas-fir is the second most abundant tree species; it and subalpine fir total ≥ 65% relative canopy cover…….....................	**ABLA-PSME d.t.p.**	**Cmix**	**C**
47b		Douglas-fir not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover....................	**48**		
	48a	Engelmann spruce is the second most abundant tree species; it and subalpine fir total ≥ 65% relative canopy cover……...............	**ABLA-PIEN d.t.p.**	**SF**	**C**

			DT or DT Phase Code	Veg Type Map Unit	Veg Grp
	48a	Engelmann spruce not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover.......	**Other ABLA d.t.**	**Cmix**	**C**
49a		Curlleaf mountain mahogany is the most abundant tree/shrub species………………………………………………………………….	**50**		
49b		Curlleaf mountain mahogany is not the most abundant tree/shrub species…………………………………………………….	**53**		
	50a	Curlleaf mountain mahogany ≥ 80% relative canopy cover………	**CELE3-CELE3 d.t.p.**	**MMmix**	**W**
	50b	Curlleaf mountain mahogany < 80% relative canopy cover………	**51**		
51a		Curlleaf mountain mahogany plus non-juniper conifer species total ≥ 65% relative canopy cover..	**CELE3-Conifer d.t.p.**	**MMmix**	**W**
51b		Curlleaf mountain mahogany plus non-juniper conifer species total < 65% relative canopy cover..	**52**		
	52a	Rocky Mountain juniper is the second most abundant tree/shrub species; it and curlleaf mountain mahogany total ≥ 65% relative canopy cover……...	**CELE3-JUSC2 d.t.p.**	**MMmix**	**W**
	52b	Rocky Mountain juniper not the second most abundant tree/shrub species and/or it and curlleaf mountain mahogany total < 65% relative canopy cover……...	**52.5**		
	52.5a	Utah juniper is the second most abundant tree/shrub species; it and curlleaf mountain mahogany total ≥ 65% relative canopy cover……...	**CELE3-JUOS d.t.p.**	**MMmix**	**W**
	52.5b	Utah juniper not the second most abundant tree/shrub species and/or it and curlleaf mountain mahogany total < 65% relative canopy cover……...	**Other CELE3 d.t.**	**MMmix**	**W**
53a		Rocky Mountain juniper is the most abundant tree/shrub species………………………………………………………………….	**54**		
53b		Rocky Mountain juniper is not the most abundant tree/shrub species………………………………………………………………….	**56**		
	54a	Rocky Mountain juniper ≥ 80% relative canopy cover…………….	**JUSC2-JUSC2 d.t.p.**	**Jmix**	**W**
	54b	Rocky Mountain juniper < 80% relative canopy cover…………….	**55**		
55a		Rocky Mountain juniper plus non-juniper conifer species total ≥ 65% relative canopy cover...	**JUSC2-Conifer d.t.p.**	**Jmix**	**W**
55b		Rocky Mountain juniper plus non-juniper conifer species total < 65% relative canopy cover...	**Other JUSC2 d.t.**	**Jmix**	**W**
	56a	Utah juniper is the most abundant tree/shrub species……………	**57**		
	56b	Utah juniper is not the most abundant tree/shrub species………..	**59**		
57a		Utah juniper ≥ 80% relative canopy cover…………………………	**JUOS-JUOS d.t.p.**	**Jmix**	**W**

			DT or DT Phase Code	Veg Type Map Unit	Veg Grp
57b		Utah juniper < 80% relative canopy cover…………………………	**58**		
	58a	Utah juniper plus non-juniper conifer species total ≥ 65% relative canopy cover..	**JUOS-Conifer d.t.p.**	**Jmix**	**W**
	58b	Utah juniper plus non-juniper conifer species total < 65% relative canopy cover..	**Other JUOS d.t.**	**Jmix**	**W**
59a		Bigtooth maple is the most abundant tree/shrub species………..	**60**		
59b		Bigtooth maple is not the most abundant tree/shrub species…….	**UNCLASSIFED**		
	60a	Bigtooth maple ≥ 80% relative canopy cover………………………	**ACGR3-ACGR3 d.t.p.**	**MPmix**	**W**
	60b	Bigtooth maple < 80% relative canopy cover………………………	**61**		
61a		Bigtooth maple plus aspen total ≥ 65% relative cover…………….	**ACGR3-POTR5 d.t.p.**	**MPmix**	**W**
61b		Bigtooth maple plus aspen total < 65% relative cover…………….	**62**		
	62a	Bigtooth maple plus non-juniper conifer species total ≥ 65% relative canopy cover...	**ACGR3-Conifer d.t.p.**	**MPmix**	**W**
	62b	Bigtooth maple plus non-juniper conifer species total < 65% relative canopy cover...	**Other ACGR3 d.t.**	**MPmix**	**W**

DRAFT Key to Shrubland Dominance Types

7/13/2012 RML, DLT

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. First identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g. valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, basin big sagebrush is in the upland key but may occur in degraded riparian areas with downcut streams.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest…………………………………………………………………….	**Go to Alpine Key (p.9) (Veg. Type MU = ALP)**
1b	Stand is located below the upper elevation limit of continuous forest……………	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables…………………………………………………………………………………….	**Go to Riparian Key (p.10)**
2b	Stand not located in a riparian setting as described above………………………	**Go to Upland Key (p.11)**

Key to Alpine Shrubland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 1. Find the name of the most abundant shrub in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more shrub species are equal in abundance, the species listed first in Table 1 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant shrub species is not listed in Table 1, then record the dominance type as UNKNOWN.

Table 1. Most Abundant Alpine Shrub and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Shrub (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Pinus albicaulis* krummholz	whitebark pine	PIAL-K	**ALP**	**A**
2	*Picea engelmannii* krummholz	Engelmann spruce	PIEN-K	**ALP**	**A**
3	*Abies lasiocarpa* krummholz	subalpine fir	ABLA-K	**ALP**	**A**
4	*Salix glauca*	grayleaf willow	SAGL	**ALP**	**A**
5	*Salix arctica*	arctic willow	SAAR27	**ALP**	**A**
6	*Salix nivalis*	snow willow	SANI8	**ALP**	**A**
7	*Ericameria suffruticosa*	singlehead goldenbush	ERSU13-A	**ALP**	**A**
8	**Species not listed above**		Undefined	**ALP**	**A**

Key to Riparian Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and vegetation type map unit can be found using Table 2a. Find the name of the most abundant shrub in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
3. When two or more shrub species are equal in abundance, the species listed first in Table 2 is used to assign the dominance type and vegetation type map unit.
4. If the most abundant shrub species is not listed in Table 2a, then record the dominance type as UNKNOWN.

Table 2a. Most Abundant Riparian Shrub and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Shrub (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Alnus viridis ssp. sinuata*	Sitka alder	ALVIS -R	**RSH**	**R**
2	*Alnus incana ssp. tenuifolia*	thinleaf alder	ALINT	**RSH**	**R**
3	*Betula occidentalis*	water birch	BEOC2	**RSH**	**R**
4	*Salix brachycarpa*	shortfruit willow	SABR	**RSH**	**R**
5	*Salix boothii*	Booth’s willow	SABO2	**RSH**	**R**
6	*Salix drummondiana*	Drummond’s willow	SADR	**RSH**	**R**
7	*Salix monticola*	park willow	SAMO2	**RSH**	**R**
8	*Salix geyeriana*	Geyer's willow	SAGE2	**RSH**	**R**
9	*Salix lemmonii*	Lemmon's willow	SALE	**RSH**	**R**
10	*Salix exigua*	coyote willow	SAEX	**RSH**	**R**

11	*Salix lutea*	yellow willow	SALU2	**RSH**	**R**
12	*Salix lucida ssp. lasiandra*	whiplash willow	SALUL	**RSH**	**R**
13	*Salix lucida ssp. caudata*	greenleaf willow	SALUC	**RSH**	**R**
14	*Salix bebbiana*	Bebb willow	SABE2	**RSH**	**R**
15	*Salix wolfii*	Wolf's willow	SAWO	**RSH**	**R**
16	*Betula glandulosa*	resin birch	BEGL	**RSH**	**R**
17	*Betula nana*	dwarf birch	BENA	**RSH**	**R**
18	*Salix eastwoodiae*	mountain willow	SAEA	**RSH**	**R**
19	*Salix planifolia*	planeleaf willow	SAPL2	**RSH**	**R**
20	*Vaccinium uglinosum*	bog blueberry	VAUL	**RSH**	**R**
21	*Ribes inerme*	whitestem gooseberry	RIIN2	**RSH**	**R**
22	*Salix* spp.	unidentified willow	SALIX	**RSH**	**R**
23	*Crataegus douglasii*	black hawthorn	CRDO2	**RSH**	**R**
24	*Cornus sericea*	redosier dogwood	COSE16	**RSH**	**R**
25	*Rhamnus alnifolia*	alderleaf buckthorn	RHAL	**RSH**	**R**
26	*Ribes hudsonianum*	northern black currant	RIHU	**RSH**	**R**
27	*Elaeagnus commutata*	silverberry	ELCO	**RSH**	**R**
28	*Rosa* spp.	roses	ROSA5-R	**RSH**	**R**
29	*Rhus trilobata*	skunkbrush sumac	RHTR	**RSH**	**R**
30	*Ribes aureum*	Golden currant	RIAU	**RSH**	**R**
31	*Dasiphora fruticosa*	shrubby cinquefoil	DAFR6	**RSH**	**R**
32	*Artemisia cana* ssp. *viscidula*	mountain silver sagebrush	ARCAV2	**RSH**	**R**
33	**Species not listed above**		Undefined	**RSH**	**R**

Key to Upland Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and vegetation type map unit can be found using Table 2b. Find the name of the most abundant shrub in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
3. When two or more shrub species are equal in abundance, the species listed first in Table 2 is used to assign the dominance type and vegetation type map unit.
4. If the most abundant shrub species is not listed in Table 2b, then record the dominance type as UNKNOWN.

Table 2b. Most Abundant Upland Shrub and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Shrub (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Alnus viridis ssp. sinuata*	Sitka alder	ALVIS-U	**FMSH**	**S**
2	*Vaccinium scoparium*	grouse whortleberry	VASC	**FMSH**	**S**
3	*Vaccinium membranaceum*	thinleaf huckleberry	VAME	**FMSH**	**S**
4	*Physocarpus malvaceus*	mallow ninebark	PHMA5	**FMSH**	**S**
5	*Acer glabrum*	Rocky Mountain maple	ACGL	**FMSH**	**S**
6	*Rubus parviflorus*	thimbleberry	RUPA	**FMSH**	**S**
7	*Sambucus racemosa*	red elderberry	SARA2	**FMSH**	**S**
8	*Salix scouleriana*	Scouler willow	SASC	**FMSH**	**S**
9	*Spiraea betulifolia*	White spiraea	SPBE2	**FMSH**	**S**
10	*Symphoricarpos albus*	common snowberry	SYAL	**FMSH**	**S**
11	*Ribes lacustre*	prickly currant	RILA	**FMSH**	**S**

12	*Mahonia repens*	creeping barberry	MARE11	**FMSH**	**S**
13	*Paxistima myrsinites*	Oregon boxleaf	PAMY	**FMSH**	**S**
14	*Juniperus communis*	common juniper	JUCO6	**FMSH**	**S**
15	*Ribes viscosissimum*	sticky currant	RIVI3	**FMSH**	**S**
16	*Ceanothus velutinus*	snowbrush ceanothus	CEVE	**FMSH**	**S**
17	*Arctostaphylos uva-ursi*	kinnikinnick	ARUV	**FMSH**	**S**
18	*Amelanchier alnifolia*	Saskatoon serviceberry	AMAL2	**FMSH**	**S**
19	*Prunus virginiana*	common chokecherry	PRVI	**FMSH**	**S**
20	*Rosa* spp.	roses	ROSA5-U	**FMSH**	**S**
21	*Symphoricarpos oreophilus*	mountain snowberry	SYOR2	**FMSH**	**S**
22	*Ribes cereum*	wax currant	RICE	**FMSH**	**S**
23	*Purshia tridentata*	bitterbrush	PUTR2	**MSB**	**S**
24	*Artemisia spiciformis*	snowfield sagebrush	ARSP8	**MSB**	**S**
25	*Artemisia tridentata ssp. vaseyana*	mountain big sagebrush	ARTRV	**MSB**	**S**
26	*Artemisia tripartita* ssp. *tripartita*	threetip sagebrush	ARTRT2	**MSB**	**S**
27	*A. t.* ssp. *wyomingensis* x *vaseyana*	Bonneville big sagebrush	ARTRB#	**SBmix**	**S**
28	*Artemisia tridentata ssp. tridentata*	basin big sagebrush	ARTRT	**SBmix**	**S**
29	*Artemisia trid. ssp. wyomingensis*	Wyoming big sagebrush	ARTRW8	**SBmix**	**S**
30	*Chrysothamnus viscidiflorus*	yellow rabbitbrush	CHVI8	**MSB**	**S**
31	*Ericameria nauseosa*	rubber rabbitbrush	ERNA10	**SBmix**	**S**
32	*Ericameria suffruticosa*	singlehead goldenbush	ERSU13	**MSB**	**S**
33	*Tetradymia canascens*	spineless horsebrush	TECA2	**SBmix**	**S**
34	*Artemisia arbuscula* ssp. *thermopola*	cleftleaf sagebrush	ARART	**DSB**	**S**
35	*Artemisia arbuscula* ssp. *longiloba*	early sagebrush	ARARL	**DSB**	**S**
36	*Artemisia arbuscula* ssp. *arbuscula*	low sagebrush	ARARA	**DSB**	**S**
37	*Artemisia nova*	black sagebrush	ARNO4	**DSB**	**S**
38	**Species not listed above**		Undefined		**S**

DRAFT Key to Grassland Dominance Types

7/13/2012 RML, DLT

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. First identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g. valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, basin big sagebrush is in the upland key but may occur in degraded riparian areas with downcut streams.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest………………………………………………………………………………………	**Go to Alpine Key (p.13) (Veg. Type MU = ALP)**
1b	Stand is located below the upper elevation limit of continuous forest…………………...	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………	**Go to Riparian Key (p.14)**
2b	Stand not located in a riparian setting as described above………………………	**Go to Upland Key (p.15)**

Key to Alpine Grassland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 3. Find the name of the most abundant graminoid in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more graminoid species are equal in abundance, the species listed first in Table 3 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 3, then record the dominance type as UNKNOWN.

Table 3. Most Abundant Alpine Graminoid and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Graminoid (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Juncus parryi*	Parry's rush	JUPA	**ALP**	**A**
2	*Juncus drummondii*	Drummond's rush	JUDR	**ALP**	**A**
3	*Carex rupestris*	curly sedge	CARU3	**ALP**	**A**
4	*Carex elynoides*	blackroot sedge	CAEL3	**ALP**	**A**
5	*Festuca brachyphylla*	alpine fescue	FEBR	**ALP**	**A**
6	*Deschampsia cespitosa*	tufted hairgrass	DECE-A	**ALP**	**A**
7	*Carex nigricans*	black alpine sedge	CANI2	**ALP**	**A**
8	*Carex nova*	black sedge	CANO3	**ALP**	**A**
9	*Phleum alpinum*	alpine timothy	PHAL2	**ALP**	**A**
10	*Poa reflexa*	nodding bluegrass	PORE	**ALP**	**A**
11	*Poa cusickii*	Cusick's bluegrass	POCU3	**ALP**	**A**
12	**Species not listed above**		Undefined	**ALP**	**A**

Key to Riparian Grassland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 4. Find the name of the most abundant graminoid in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more graminoid species are equal in abundance, the species listed first in Table 4 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 3, then record the dominance type as UNKNOWN.

Table 4. Most Abundant Riparian Graminoid and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Graminoid (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Schoenplectus acutus var. acutus*	hardstem bulrush	SCACA	**RHE**	**R**
2	*Schoenplectus pungens*	common threesquare	SCPU10	**RHE**	**R**
3	*Carex simulata*	analogue sedge	CASI2	**RHE**	**R**
4	*Carex scopulorum*	mountain sedge	CASC12	**RHE**	**R**
5	*Eleocharis palustris*	common spikerush	ELPA3	**RHE**	**R**
6	*Eleocharis quinqueflora*	fewflower spikerush	ELQU2	**RHE**	**R**
7	*Eleocharis rostellata*	beaked spikerush	ELRO2	**RHE**	**R**
8	*Carex lasiocarpa*	woollyfruit sedge	CALA11	**RHE**	**R**
9	*Carex limosa*	mud sedge	CALI7	**RHE**	**R**
10	*Carex livida*	livid sedge	CALI	**RHE**	**R**
11	*Carex atherodes*	wheat sedge	CAAT2	**RHE**	**R**
12	*Calamagrostis stricta*	slimstem reedgrass	CAST36	**RHE**	**R**
13	*Carex buxbaumii*	Buxbaum’s sedge	CABU6	**RHE**	**R**

14	*Carex aquatilis*	water sedge	CAAQ	**RHE**	**R**
15	*Carex utriculata*	NW Territory sedge	CAUT	**RHE**	**R**
16	*Carex vesicaria*	blister sedge	CAVE6	**RHE**	**R**
17	*Calamagrostis canadensis*	bluejoint reedgrass	CACA4	**RHE**	**R**
18	*Carex nesbrascensis*	Nebraska sedge	CANE2	**RHE**	**R**
19	*Carex athrostachya*	slenderbeak sedge	CAAT3	**RHE**	**R**
20	*Carex amplifolia*	bigleaf sedge	CAAM10	**RHE**	**R**
21	*Deschampsia cespitosa*	tufted hairgrass	DECE-R	**RHE**	**R**
22	*Danthonia intermedia*	timber oatgrass	DAIN	**RHE**	**R**
23	*Danthonia californica*	California oatgrass	DACA3	**RHE**	**R**
24	*Carex microptera*	smallwing sedge	CAMI7	**RHE**	**R**
25	*Poa palustris*	fowl bluegrass	POPA2	**RHE**	**R**
26	*Carex praegracilis*	clustered field sedge	CAPR5	**RHE**	**R**
27	*Alopecurus aequalis*	shortawn foxtail	ALAE	**RHE**	**R**
28	*Phalaris arundinacea*	reed canarygrass	PHAR3	**RHE**	**R**
29	*Carex douglasii*	Douglas' sedge	CADO2	**RHE**	**R**
30	*Agrostis stolonifera*	creeping bentgrass	AGST2	**RHE**	**R**
31	*Agrostis humilis*	alpine bentgrass	AGHU	**RHE**	**R**
32	*Juncus arcticus* ssp. *littoralis*	mountain rush	JUARL	**RHE**	**R**
33	*Juncus confusus*	Colorado rush	JUCO2	**RHE**	**R**
34	*Juncus longistylis*	longstyle rush	JULO	**RHE**	**R**
35	*Alopecurus pratensis*	meadow foxtail	ALPR3	**RHE**	**R**
36	*Phleum pretense*	common timothy	PHPR3-R	**RHE**	**R**
37	*Leymus cinereus*	basin wildrye	LECI4-R	**RHE**	**R**
38	*Poa pratensis*	Kentucky bluegrass	POPR-R	**RHE**	**R**
39	*Hordeum brachyantherum*	meadow barley	HOBR2	**RHE**	**R**
40	**Species not listed above**		Undefined	**RHE**	**R**

Key to Upland Grassland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 4. Find the name of the most abundant graminoid in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more graminoid species are equal in abundance, the species listed first in Table 4 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 5, then record the dominance type as UNKNOWN.
4. Use Table 5A below to assign plots dominated by a native species to a map unit.

Table 5. Most Abundant Upland Graminoid and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Graminoid (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Calamagrostis rubescens*	pinegrass	CARU	**See Table 5A**	**H**
2	*Carex geyeri*	elk sedge	CAGE2	**See Table 5A**	**H**
3	*Carex rossii*	Ross' sedge	CARO5	**See Table 5A**	**H**
4	*Bromus marginatus*	mountain brome	BRMA4	**See Table 5A**	**H**
5	*Carex hoodii*	Hood's sedge	CAHO5	**See Table 5A**	**H**
6	*Leucopoa kingii*	spikefescue	LEKI2	**See Table 5A**	**H**
7	*Melica spectabilis*	purple oniongrass	MESP	**See Table 5A**	**H**
8	*Elymus trachycaulus*	slender wheatgrass	ELTR7	**See Table 5A**	**H**
9	*Festuca idahoensis*	Idaho fescue	FEID	**See Table 5A**	**H**
10	*Pseudoroegneria (Agropyron) spicata*	bluebunch wheatgass	PSSP6	**See Table 5A**	**H**

11	*Hesperostipa comata*	needle-and-thread	HECO26	**See Table 5A**	**H**
12	*Poa secunda*	Sandberg's bluegrass	POSE	**See Table 5A**	**H**
13	*Leymus cinereus*	basin wildrye	LECI4-U	**See Table 5A**	**H**
14	*Koeleria macrantha*	Prairie junegrass	KOMA	**See Table 5A**	**H**
15	*Spartina gracilis*	alkali cordgrass	SPGR	**See Table 5A**	**H**
16	*Spartina airoides*	alkali sacaton	SPAI	**See Table 5A**	**H**
17	*Pascopyrum smithii*	western wheatgrass	PASM	**See Table 5A**	**H**
18	*Elymus lanceolatus*	thickspike wheatgrass	ELLA3	**See Table 5A**	**H**
19	**Native species not listed above**		Undefined	**See Table 5A**	**H**
20	*Phleum pretense*	common timothy	PHPR3-U	**RGR**	**H**
21	*Poa pratensis*	Kentucky bluegrass	POPR-U	**RGR**	**H**
22	*Bromus inermis*	smooth brome	BRIN2	**RGR**	**H**
23	*Agropyron cristatum*	crested wheatgrass	AGCR	**RGR**	**H**
24	*Thinopyrum (Agropyron) intermedium*	intermediate wheatgrass	THIN6	**RGR**	**H**
25	*Psathyrostachys juncea*	Russian wildrye	PSJU3	**RGR**	**H**
26	*Elymus repens*	quackgrass	ELRE4	**RGR**	**H**
27	Unidentified Non-Native wheatgrass		NNWG	**RGR**	**H**
28	*Bromus tectorum*	cheatgrass	BRTE	**RGR**	**H**
29	*Poa bulbosa*	bulbous bluegrass	POBU	**RGR**	**H**
30	**Non-native species not listed above**		Undefined	**RGR**	**H**

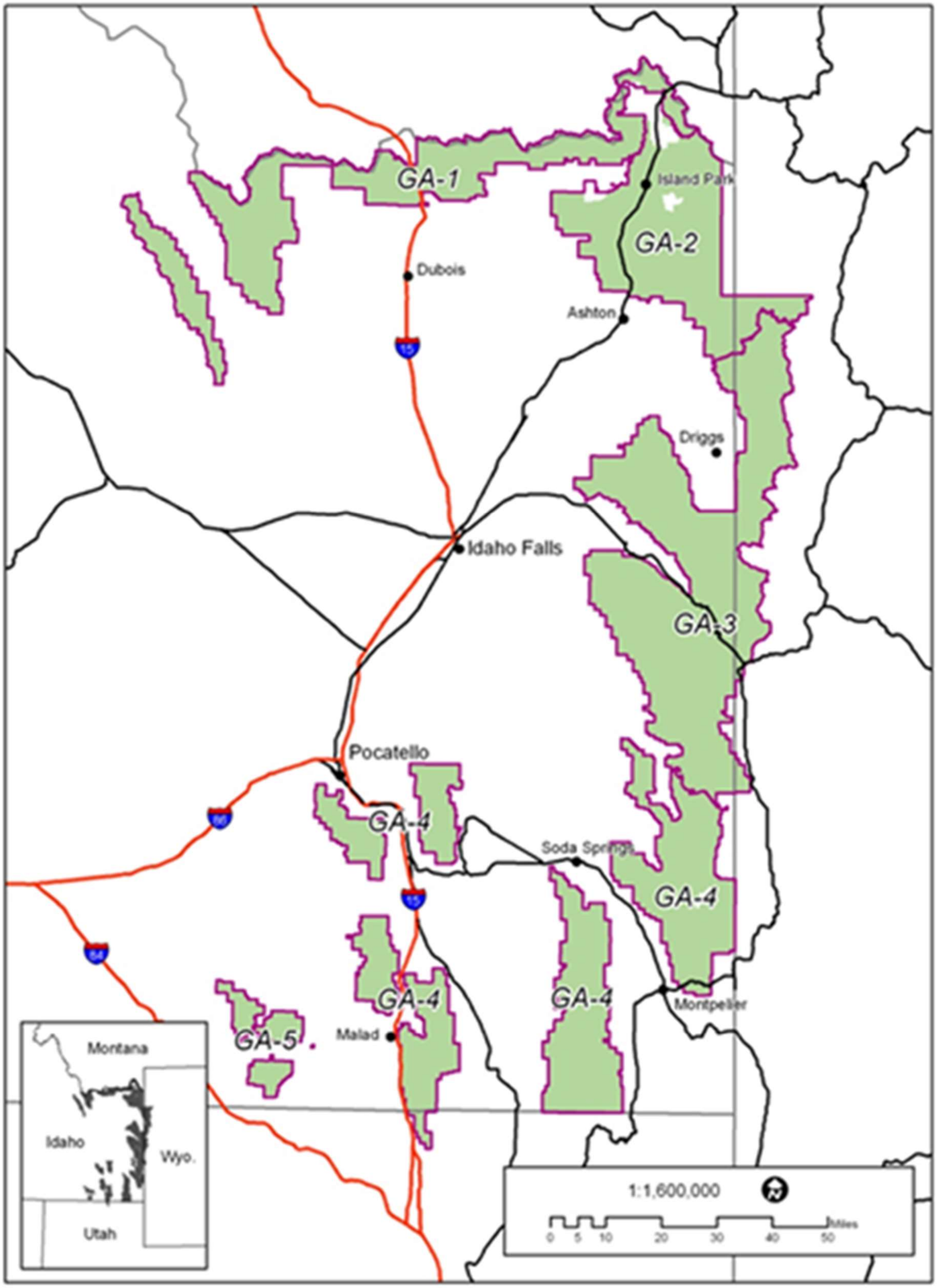
Key to Herbaceous Upland Map Units

Instructions:

1. Determine which Geographical Area (G.A.) in which the plot is located and the elevation of the plot.
2. Use Table 5A to assign the map unit based on G.A. and elevation.

Table 5A. Upland Herbaceous Map Based on Elevation and G.A.

<table>
<tr><th>Elevation</th><th>GA1</th><th>GA3</th><th>GA4</th></tr>
<tr><td>≥ 9200</td><td rowspan="2">ALP</td><td>ALP</td><td rowspan="3">SUBH</td></tr>
<tr><td>8900 – 9199</td><td rowspan="4">SUBH</td></tr>
<tr><td>7900 – 8899</td><td rowspan="2">SUBH</td></tr>
<tr><td>7800 – 7899</td><td rowspan="3">MTNH</td></tr>
<tr><td>7700 – 7799</td><td rowspan="2">MTNH</td></tr>
<tr><td>< 7700</td><td>MTNH</td></tr>
</table>


GA-1
GA-2
GA-3
GA-4
GA-4
GA-4
GA-4
GA-5
Island Park
Dubois
Ashton
Driggs
Idaho Falls
Pocatello
Soda Springs
Montpelier
Malad
Montana
Idaho
Wyo.
Utah
1:1,600,000
0 5 10 20 30 40 50
Miles

DRAFT Key to Forbland Dominance Types

7/13/2012 RML, DLT

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. First identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g. valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, basin big sagebrush is in the upland key but may occur in degraded riparian areas with downcut streams.

Key to Physical Habitat Setting

Key Leads:

1a		Stand is located in an alpine setting above the upper elevation limit of continuous forest……………………………………………………………………	**Go to Alpine Key (p.17) (Veg. Type MU = ALP)**
1b		Stand is located below the upper elevation limit of continuous forest……………	**2**
	2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………	**Go to Riparian Key (p.17)**
	2b	Stand not located in a riparian setting as described above……………………….	**Go to Upland Key (p.18)**

Key to Alpine Forbland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 6. Find the name of the most abundant forb in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more forb species are equal in abundance, the species listed first in Table 6 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant forb species is not listed in Table 6, then record the dominance type as UNKNOWN.

Table 6. Most Abundant Alpine Forb and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Forb (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Caltha leptosepala*	white marsh marigold	CALE4-A	**ALP**	**A**
2	*Polygonum bistortoides*	Bistort knotweed	POBI6	**ALP**	**A**
3	*Geum rossii*	Ross' avens	GERO2	**ALP**	**A**
4	*Trifolium haydenii*	Hayden's clover	TRHA	**ALP**	**A**
5	*Potentilla diversifolia*	varileaf cinquefoil	PODI2	**ALP**	**A**
6	*Potentilla ovina*	sheep cinquefoil	POOV2	**ALP**	**A**
7	*Dryas octopetala*	Eightpetal mountain-avens	DROC	**ALP**	**A**
8	*Astragalus kentrophyta*	spiny milkvetch	ASKE	**ALP**	**A**
9	*Arenaria aculeata*	prickly sandwort	ARAC2	**ALP**	**A**
10	*Phlox pulvinata*	cushion phlox	PHPU5	**ALP**	**A**
11	*Ivesia gordonii*	Gordon's ivesia	IVGO	**ALP**	**A**
12	*Polygonum phytolaccifolium*	poke knotweed	POPH	**ALP**	**A**
13	**Species not listed above**		Undefined	**ALP**	**A**

Key to Riparian Forbland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 6. Find the name of the most abundant forb in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more forb species are equal in abundance, the species listed first in Table 6 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant forb species is not listed in Table 7, then record the dominance type as UNKNOWN.

Table 7. Most Abundant Riparian Forb and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Forb (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Nuphar lutea ssp. polysepala*	Rocky Mountain pond-lily	NULUP	**RHE**	**R**
2	*Typha latifolia*	broadleaf cattail	TYLA	**RHE**	**R**
3	*Caltha leptosepala*	white marsh marigold	CALE4-R	**RHE**	**R**
4	*Senecio triangularis*	arrowleaf ragwort	SETR	**RHE**	**R**
5	*Mertensia ciliata*	tall fringed bluebells	MECI3	**RHE**	**R**
6	*Maianthemum stellatum*	Starry false lily of the valley	MAST4	**RHE**	**R**
7	*Veratrum californicum*	California false hellebore	VECA2	**RHE**	**R**
8	**Species not listed above**		Undefined	**RHE**	**R**

Key to Upland Forbland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 8. Find the name of the most abundant forb in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more forb species are equal in abundance, the species listed first in Table 8 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant forb species is not listed in Table 8, then record the dominance type as UNKNOWN.
4. Use Table 5A above to assign plots dominated by a native species to a map unit.

Table 8. Most Abundant Upland Forb and Indicated Dominance Type and Veg. Type Map Unit.

(1) Rank	(2) Most Abundant Forb (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Ligusticum filicinum*	fernleaf licorice-root	LIFI	**See Table 5A**	**H**
2	*Delphinium* X *occidentale*	tall larkspur	DEOC	**See Table 5A**	**H**
3	*Agastache urticifolia*	nettleleaf horsemint	AGUR	**See Table 5A**	**H**
4	*Eucephalus engelmannii*	Engelmann's aster	EUEN	**See Table 5A**	**H**
5	*Erigeron peregrinus*	subalpine fleabane	ERPE3	**See Table 5A**	**H**
6	*Artemisia ludoviciana*	Louisiana sagewort	ARLU	**See Table 5A**	**H**
7	*Balsamorhiza macrophylla*	cutleaf balsmroot	BAMA4	**See Table 5A**	**H**
8	*Delphinium glaucescens*	smooth larkspur	DEGL2	**See Table 5A**	**H**
9	*Balsamorhiza sagittata*	arrowleaf balsamroot	BASA3	**See Table 5A**	**H**
10	*Helianthella uniflora*	oneflower helianthella	HEUN	**See Table 5A**	**H**
11	*Geranium viscosissimum*	sticky geranium	GEVI2	**See Table 5A**	**H**

12	*Chamerion angustifolium*	fireweed	CHAN9	**See Table 5A**	**H**
13	*Illiamna rivularis*	Streambank wild hollyhock	ILRI	**See Table 5A**	**H**
14	*Rudbeckia occidentalis*	western coneflower	RUOC2	**See Table 5A**	**H**
15	*Wyethia amplexicaulis*	mule-ears	WYAM	**See Table 5A**	**H**
16	*Wyethia helianthoides*	sunflower mule-ears	WYHE2	**See Table 5A**	**H**
17	*Eurybia (Aster) integrifolia*	thickstem aster	EUIN9	**See Table 5A**	**H**
18	*Valeriana sitchensis*	Sitka valerian	VASI	**See Table 5A**	**H**
19	*Thalictrum occidentale*	western meadow-rue	THOC	**See Table 5A**	**H**
20	*Pteridium aquilinum*	western brackenfern	PTAQ	**See Table 5A**	**H**
21	*Lomatium bicolor*	Wasatch desertparsley	LOBI	**See Table 5A**	**H**
22	*Potentilla gracilis*	slender cinquefoil	POGR9	**See Table 5A**	**H**
23	*Potentilla glandulosa*	sticky cinquefoil	POGL9	**See Table 5A**	**H**
24	*Arnica cordifolia*	heartleaf arnica	ARCO9	**See Table 5A**	**H**
25	*Fragaria virginiana*	Virginia strawberry	FRVI	**See Table 5A**	**H**
26	*Hieracium cynoglossoides*	houndstongue hawkweed	HICY	**See Table 5A**	**H**
27	*Lupinus argenteus*	silvery lupine	LUAR3	**See Table 5A**	**H**
28	*Lupinus sericeus*	silky lupine	LUSE4	**See Table 5A**	**H**
29	*Lupinus arbustus*	longspur lupine	LUAR6	**See Table 5A**	**H**
30	*Lupinus wyethii*	Wyeth's lupine	LUWY	**See Table 5A**	**H**
31	*Achillea millefolium*	western yarrow	ACMI2	**See Table 5A**	**H**
32	*Eriogonum heracleoides*	parsnipflower buckwheat	ERHE2	**See Table 5A**	**H**
33	*Erigeron compositus*	cutleaf daisy	ERCO4	**See Table 5A**	**H**
34	*Monardella odoratissima*	mountain monardella	MOOD	**See Table 5A**	**H**
35	*Eriogonum umbellatum*	sulphur-flower buckwheat	ERUM	**See Table 5A**	**H**
36	*Phlox multiflora*	flowery phlox	PHMU3	**See Table 5A**	**H**
37	*Phlox hoodii*	spiny phlox	PHHO	**See Table 5A**	**H**
38	*Antennaria media*	Rocky Mountain pussytoes	ANME2	**See Table 5A**	**H**

39	*Antennaria microphylla*	littleleaf pussytoes	ANMI3	**See Table 5A**	**H**
40	*Euphobia esula*	leafy spurge	EUES	**See Table 5A**	**H**
41	*Madia glomerata*	mountain tarweed	MAGL2	**See Table 5A**	**H**
42	*Centaurea stoebe*	spotted knapweed	CEST8	**See Table 5A**	H
43	*Petrophytum caespitosum*	mat rockspirea	PECA12	**See Table 5A**	**H**
44	*Epilobium brachycarpum*	tall annual wilowweed	EPBR3	**RGR**	**H**
45	*Sisymbrium altissimum*	tall tumblemustard	SIAL2	**RGR**	**H**
46	*Gayphytum diffusum*	Spreading groundsmoke	GADI2	**RGR**	**H**
47	*Polygonum douglasii*	Douglas' knotweed	PODO4	**RGR**	**H**
48	*Chorispora tenella*	crossflower	CHTE2	**RGR**	**H**
49	*Cirsium arvense*	Canada thistle	CIAR4	**RGR**	**H**
50	*Linaria dalmatica*	Dalmatian toasdflax	LIDA	**RGR**	**H**
51	*Linaria vulgaris*	butter and eggs	LIVU2	**RGR**	**H**
52	**Species not listed above**		Undefined	**See Table 5A**	**H**

Key to Non-Vegetated Land Cover and Land Use Types

05/11/2010 DLT

Veg. Group

1a. Area is currently used for agricultural activity (e.g. a fallow field). . . . . **Agriculture (AGR)**
N

1b. Area is not currently used for agricultural activity 2

2a. Area is currently developed for urban, residential, administrative use . . . . . **Developed (DEV)**
N

2b. Area is not currently developed for urban, residential, administrative use 3

3a. Area is dominated by open water or a confined water coarse . . . . **Water (WA)**
N

3b. Area is not dominated by open water or a confined water coarse 4

4a. Area is dominated by unburned barren land (e.g. bare ground, bedbrock,

scree/tallus, mines/talings) . . . . **Barren/Rock (BR/SV)**
N

4b. Area is not dominated by unburned barren land 5

5. Area not as above. . . . . **Unclassified**

Appendix A. Absolute and Relative Cover

Absolute cover of a plant species is the proportion of a plot's area included in the perpendicular downward projection of the species. These are the values recorded when sampling a vegetation plot. Relative cover of a species is the proportion it comprises of the total plant cover on the plot (or the proportion of a layer's cover). Relative cover values must be calculated from absolute cover values. For example, we estimate overstory canopy cover on a plot as follows: lodgepole pine 42%, Engelmann spruce 21%, and subalpine fir 7%. These values are the absolute cover of each species. The relative cover of each species is calculated by dividing each absolute cover value by their total (70%) as follows:

	Absolute Cover	Calculation	Relative Cover
Lodgepole pine	42%	100 x 42 / 70 =	60%
Engelmann spruce	21%	100 x 21 /70 =	30%
Subalpine fir	7%	100 x 7 /70 =	10%
Total of values	70%		100%

We calculate relative cover of 60% for lodgepole pine. This means that lodgepole pine makes up 60% of the overstory tree canopy cover on the plot. Relative cover always adds up to 100%, but absolute cover does not. Because plant canopies can overlap each other, absolute cover values can add up to more than 100%. In our example, the total of the absolute cover values is 70, but this does not mean that overstory trees cover 70% of the plot. Overstory tree cover would be 70% if there were no overlap between the crowns of the three species, but only 42% with maximum overlap. The actual overstory cover must be determined when sampling the plot if the information is desired, but the sum of the species cover values is used to calculate relative cover.

If the absolute cover values in our example were all halved or all doubled, the relative cover of each species would not change even though overstory tree cover would be very different. Halving the absolute values would mean overstory cover would be between 21 and 35%, depending on the amount of overlap. Doubling the values would mean overstory cover could range from 84 to 100% (not 140%). Each of these scenarios would be very different from the original example in terms of wildlife habitat value, fuel conditions, fire behavior, and silvicultural options; but the relative cover of the tree species would be exactly the same. We should also note that they also could vary widely in spectral signature. The key point here is that relative cover values by themselves provide limited ecological information and may be of little value to resource managers. Relative cover can be derived from absolute cover, but absolute cover cannot be derived from relative cover values. This is why absolute cover is recorded in the field.

Appendix B. Vegetation Group and Vegetation Type Map Unit Codes

Vegetation Group	Code
Alpine	**A**
Conifer Forest	**C**
Deciduous Forest	**D**
Herbaceous	**H**
Non-Vegetated/ Sparse Vegetation	**N**
Riparian	**R**
Shrubland	**S**
Woodland	**W**

Vegetation Type Map Unit	Code
Alpine	
Alpine Vegetation	**ALP**
Riparian	
Riparian Shrubland and Deciduous Forest	**RSH**
Riparian Herbaceous	**RHE**
Herbaceous	
Ruderal Grasslands (Non-native grasslands & weedy herbaceous)	**RGR**
Subalpine Herbaceous	**SUBH**
Montane Herbaceous	**MTNH**
Shrubland	
Dry Big Sagebrush Mix	**SBmix**
Dwarf Sagebrush	**DSB**
Forest/Mountain Shrublands	**FMSH**
Mountain Big Sagebrush	**MSB**
Forest and Woodland	
Woodland	
Bigtooth Maple Mix	**MPmix**
Juniper Mix	**Jmix**
Mountain Mahogany Mix	**MMmix**
Conifer	
Conifer Mix	**Cmix**
Douglas-fir	**DF**
Douglas-fir/Lodgepole Pine	**DF/LP**
Limber Pine/Douglas-fir	**LM/DF**
Lodgepole Pine	**LP**
Spruce/Fir	**SF**
Whitebark Pine Mix	**WBmix**
Deciduous	
Aspen	**AS**
Aspen/Conifer	**AS/C**
Conifer/Aspen	**C/AS**
Non-Vegetated/Sparse Vegetation	
Barren/ Sparse Vegetation	**BR/SV**
Agriculture	**AGR**
Developed	**DEV**
Water	**WA**

Appendix IV: Acquired Geospatial Data For Mapping

Geospatial data acquired for the mapping process, showing data source and how it was used in the mapping process.

Geospatial Data	Source	Use
Landsat Thematic Mapper– spring scenes	USGS Glovis	Modeling
Landsat Thematic Mapper – summer scenes	USGS Glovis	Modeling
Landsat Thematic Mapper – fall scenes	USGS Glovis	Modeling
NAIP (1.0-meter)	USDA Farm Service Agency	Modeling & Segmentation
Resource photography (0.5- meter)	Region 4 Regional Office	Modeling
Digital Elevation Model (DEM)	i-cubed DataDoors	Modeling & Segmentation
Administrative boundary	Caribou-Targhee NF	Identify project area
Land ownership	Caribou-Targhee NF	Field site selection
Roads & trails	Caribou-Targhee NF	Field site selection
Hydrology	Caribou-Targhee NF	Field site selection
EUI ecological type (Targhee only)	Caribou-Targhee NF	Modeling
Soil resource inventory (Caribou only)	Caribou-Targhee NF	Modeling
FACTS	Caribou-Targhee NF	Modeling & Editing
IfSAR	Intermap Technologies	Size class modeling
Fire severity & burn perimeters	MTBS	Modeling
Climate – temperature	Daymet	Modeling
Climate – frost days	Daymet	Modeling
Climate – growing days	Daymet	Modeling
Climate – precipitation	Daymet	Modeling
Climate – relative humidity	Daymet	Modeling
Climate – solar radiation	Daymet	Modeling

Appendix V: eCognition's Layer Weight

Layer weights used to develop the modeling units (segments) in eCognition software.

Layer	Upland Weight	Riparian Weight
NAIP Band 1 (Red)	1	1
NAIP Band 2 (Green)	1	1
NAIP Band 3 (Blue)	1	1
NAIP Band 4 (NIR)	1	1
NAIP NDVI	1	1
Landsat PC1	1	1
Landsat Tasseled Cap Band 2 (Greenness)	0	1
Landsat Tasseled Cap Band 3 (Wetness)	0	1
Fully Illuminated Hillshade Band 1	.3	.3
Fully Illuminated Hillshade Band 2	.3	.3
Fully Illuminated Hillshade Band 3	.3	.3

Appendix VI: Field Reference Data Collection Guide & Protocols

Caribou-Targhee National Forest
Existing Vegetation Mapping Project
Field Reference Data Collection Guide & Protocols
5/27/2011

Introduction

This document will serve as a guide to reference data collection for the Caribou-Targhee National Forest Existing Vegetation Mapping Project. Detailed instructions on how to fill out the datasheets are included in this document. These protocols have been established following the USFS Existing Vegetation Classification and Mapping Technical Guide as well as guidelines from the Remote Sensing Applications Center.

Background

The Caribou-Targhee National Forest is responsible for managing vegetation to meet a variety of uses while sustaining and restoring the integrity, biodiversity, and productivity of ecosystem components and processes. In building the knowledgebase required to accomplish this mission, existing vegetation information is collected through an integrated classification, mapping, and quantitative inventory process. This information structure is essential for conducting landscape analyses and assessments, developing conservation and restoration strategies, and revising land management plans that guide project development and implementation.

The data you collect will be used to create a mid-level (1:100,000 scale) map of current (existing) vegetation communities across the Caribou-Targhee National Forest and Curlew National Grassland. Data gathered will include information on species composition, forest and shrub canopy cover, and tree size class. The data will be estimated from a “bird’s eye” or “satellite” view from above. Vegetation canopy overlap will not be considered. Estimations will be done using a combination of ocular estimates and transects.

Tools

You have been provided several tools to assist in the field data collection process. They include:

- Dominance type key
- Field data collection forms
- Field overview maps (1:160,000 scale)
- Field travel maps (1:20,000 scale)
- Plot maps (1:9,000 scale)

General Data Collection Procedures

Field information will be collected from three types of plots:

- Pre-selected field plots
- Field observation polygons
- Opportunistic field plots

Pre-Selected Field Plots

The Caribou-Targhee project area has been divided into 5 geographic areas (Figure 1). Approximately 200-300 pre-selected field plots have been identified for each geographic area (GA) with the exception of the Curlew National Grassland with about 50 plots. These plots were chosen using spectral information from Landsat Thematic Mapper satellite imagery, elevation, slope, and aspect. They are not a random sample of the mapping area and have not been established along a sample grid or other sampling procedure. Plots were selected in vegetative homogenous areas generally within a quarter mile of a road or along trails. Some plots may be behind closed roads or in roadless areas.

The pre-selected field plots should provide a sample of the landcover communities that occur on the National Forest and Grassland. For each plot, the composition, canopy cover, and tree size data will be used to determine the vegetation dominance type and the following vegetation map classes (map units): vegetation group, vegetation type, canopy cover, and tree size.

Field Observation Polygons

A minimum of 3, and optionally 4, additional field observation polygons will be collected with each of the pre-selected field plots. You will use the plot maps (1-meter resolution NAIP aerial imagery and segment polygons) to identify observation polygons containing homogenous vegetation and estimate the vegetation group, dominance type, vegetation type, canopy cover class, and tree size class. This provides an opportunity to quickly collect additional vegetation information.

Opportunistic Field Plots

Opportunistic plots can be established for those existing vegetation types that lack adequate representation in the sample. Opportunistic plots are meant to be collected as crews travel to and from the pre-selected plots. Up to a total of 200 opportunistic plots may be established by crews in addition to the pre-selected plots. Opportunistic plots follow the same data collection protocols as the pre-selected plots.

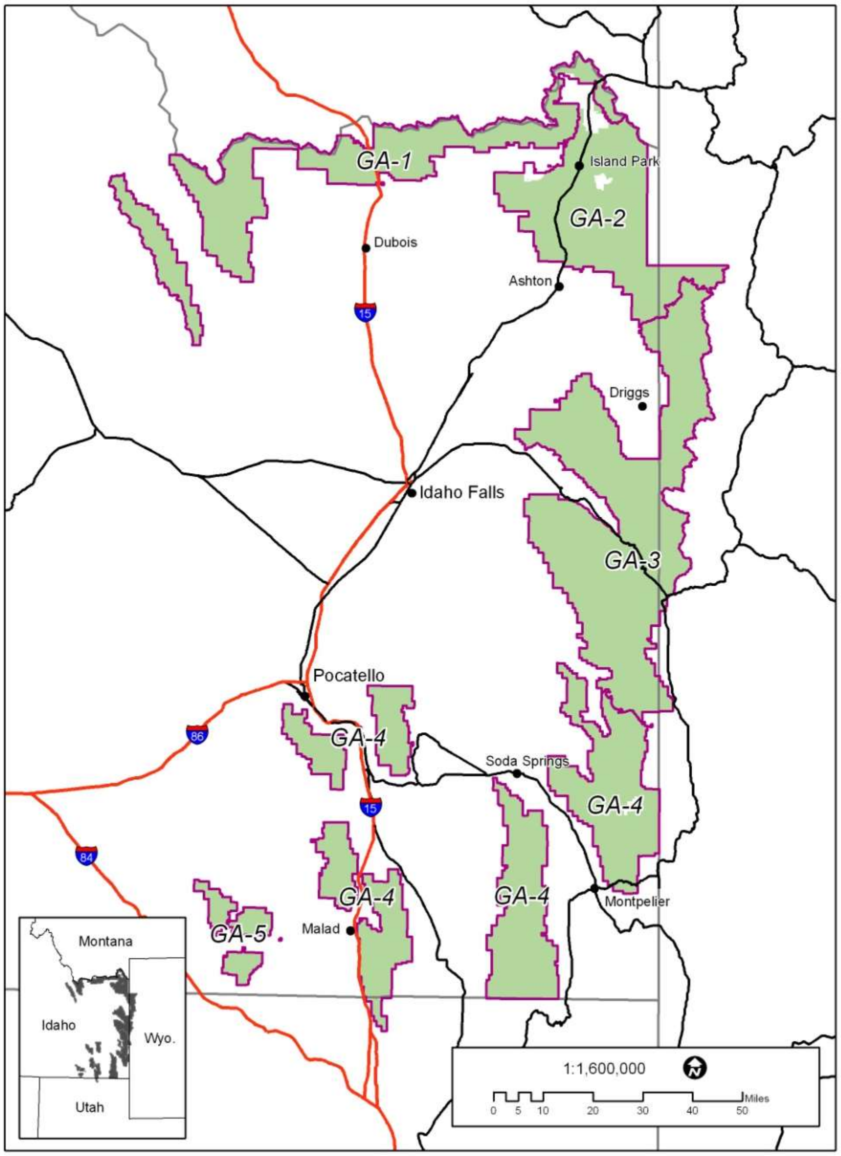


Figure 1. Project Geographic Areas (GA's).

Sampling Process and Data Collection Procedures

The sampling process contains three steps: planning, navigation, and data collection.

Step 1 - Planning

Before leaving the office, each crew should know where they are going, what information is going to be collected, and have the appropriate gear to complete the task. Review the overview maps and travel maps to determine the best travel routes. Check with your supervisor and/or crew lead before leaving. Coordination with designated Forest personnel to ensure access should be completed before leaving for field.

To ensure unique plot numbers are assigned to the collection of *opportunistic* plots, a set of available plot numbers for each GA should be allocated amongst the crews prior to commencing field work. For example, for GA-1, Crew 1 could be assigned plot numbers 1500 to 1519; Crew 2, 1520-1539, etc. The first digit in the plot number refers to the GA number.

All plots collected must be within the project boundary (i.e. on NF lands designated for the project). They cannot be adjacent to lands of the project boundary. It is the responsibility of the field crew to assure that plots are within the project boundary.

If any plots are revisited, they cannot be labeled as *moved* or *opportunistic* and given a second number. It is the responsibility of field crew members to keep track of plots visited and who has been assigned to visit a particular plot.

Gear check list:

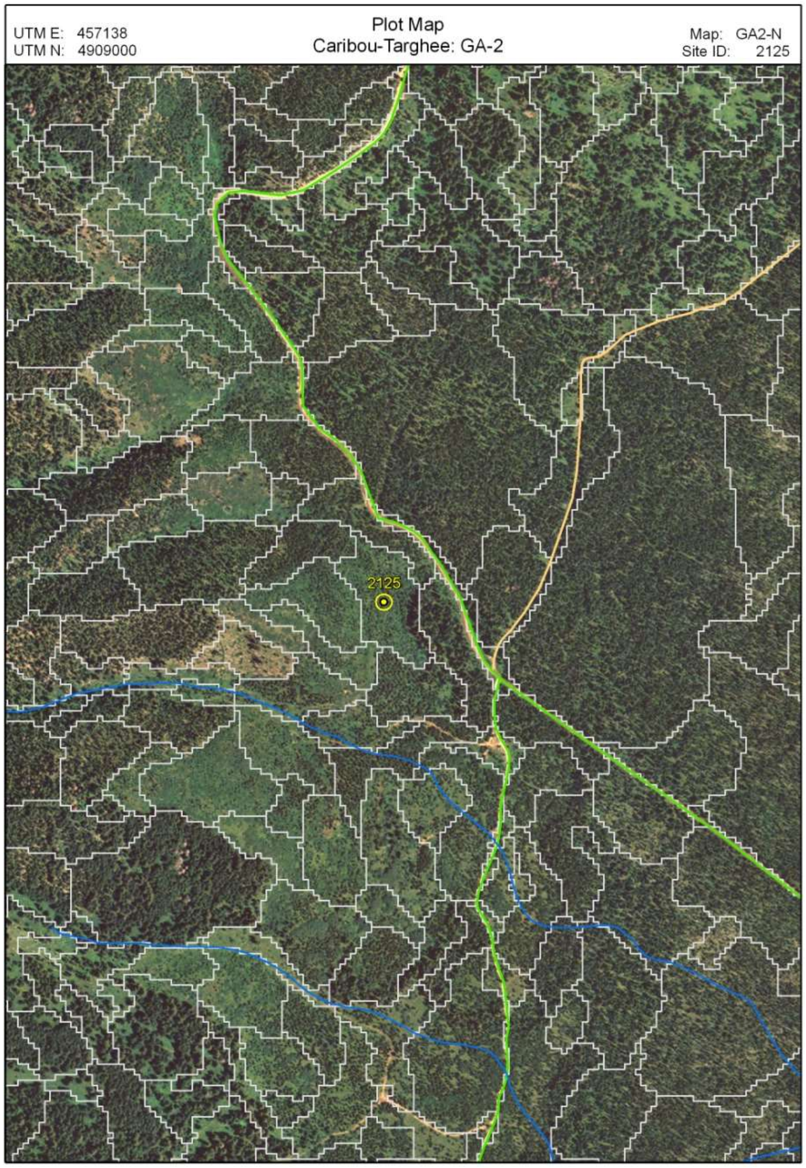
- GPS unit
- Digital camera
- Batteries (GPS and Camera)
- Data sheets
- Dominance type key
- Travel maps & plot maps
- Pencils & sharpies
- Clinometer
- 100m tape
- 100ft tape
- DBH tape
- Compass
- Flagging
- Pin Flags
- Whiteboard

Step 2 - Navigation

You have been provided with the coordinates of the pre-selected field plot center, and navigation and plot maps with 2009 NAIP aerial imagery in the background to help with navigating to the plot. The waypoints should be pre-loaded on the GPS unit. Plots have been located generally within a ¼ mile of a road or along trails to make them as accessible as possible.

However, there is no guarantee that the plots will be accessible. If you cannot get to the plot, but can clearly see it from some vantage point, fill out as much information as possible and note the plot as viewed from a distance. If a plot is completely inaccessible and cannot be viewed, note that the plot is not observable, and either go on to the next plot location or move the plot to a nearby area comprised of similar vegetation and topographic characteristics as identified on the plot map including vegetation type, aspect, and slope. If a plot is relocated, note the plot as a moved on the field form. Do not assign a new plot number to a moved plot or record it as an *opportunistic* plot.

As you navigate between pre-selected field plots, look for vegetation types that have not been adequately sampled. A list of underrepresented types will be provided by the Forest Service at regular intervals throughout the field season. Collect an opportunistic field plot using a new field form, assign a new plot number, and note the plot as an opportunistic plot.



Plot map showing pre-selected field plot locations, roads (color-coded by type), streams, and segment polygons.

__Step 3- Data Collection__

- Pre-selected field plots

Once you arrive at the field plot, make sure it is representative of the segment polygon as identified on the plot map. Walk through the segment area 100-200 feet around the plot center. If the pre-selected plot is not representative of the segment polygon, move the plot center to a more representative location within the segment. This option should be used with caution and good judgment. If the segment is very heterogeneous, sample the most representative vegetation community type (i.e. of which type the segment is mostly comprised). In the Notes section of the field form, include rationale for moving the plot, and details of dominance composition with the segment.

The size of each plot is a 50 foot radius circle. Once the location of the plot has been determined, place flagging or a pin flag at the plot center. Pace or measure and flag the plot boundaries in each cardinal direction from the center of the plot. In designated Wilderness Areas, use sticks or rock cairns to mark the plot instead of flagging. Estimate all vegetation data within the plot area from a "bird's eye" view or top-down perspective. It is important to walk through the entire plot before estimating species, canopy cover, and tree size class. It may also be helpful to mark out a 5 foot radius subplot representing 1 percent of the plot area to assist in calibrating your estimates.

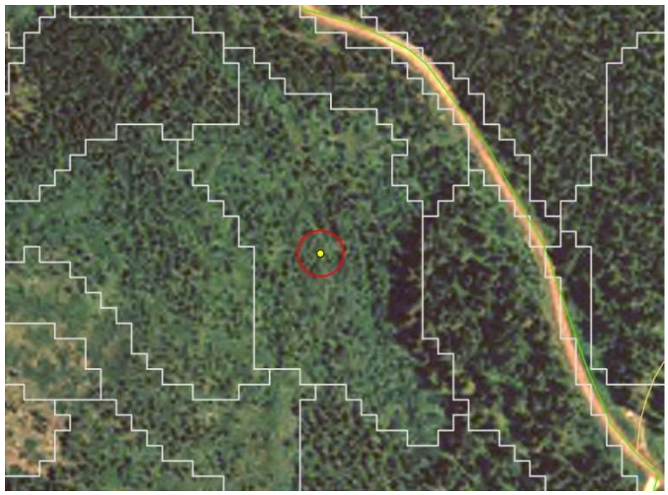
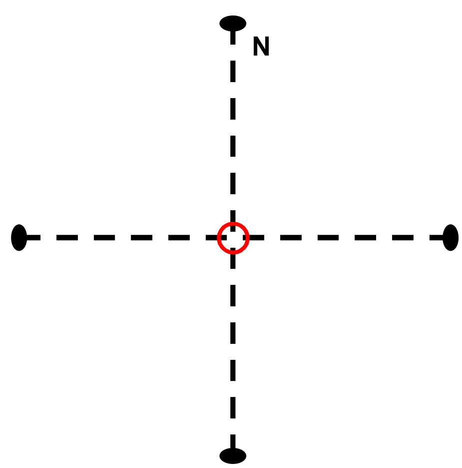


Image map showing plot center location and corresponding 50 foot radius plot boundary within a segment polygon representing relatively homogeneous vegetation.



For the first 5 shrubland plots per observer, use the transect intercept method to determine the shrub canopy cover to calibrate subsequent ocular estimates. For every 3-5 shrubland plots thereafter (per observer), use the transect intercept method to maintain consistency of your ocular estimates. The intercept method involves laying out two perpendicular 100-foot transects through the plot center; one running north-south and one running east-west, using tapes and stakes. Do not allow the vegetation to deflect the alignment of the tape. Estimate and record the number of feet of live canopy cover intercepted for each species within each 10-foot transect increment. Round the estimate to the nearest 0.5 foot for each 10-foot increment. Gaps within a single plant, flowers, and flower stalks should be counted as part of the shrub. The total for each transect is the canopy percentage. The N/S transect and E/W transect percentages are then averaged to calculate the overall shrub canopy cover.

- Field Observation Polygons

For each of the pre-selected field plots, 3 to 4 field observation polygons will be collected using the plot map (1:9000 scale with NAIP imagery as a backdrop). On the plot map, identify a segment polygon representing an area of homogenous vegetation, label it A, B, C, or D, and fill in the appropriate information on the left side of the back of the field plot form. Here you will provide general information on the vegetation group, dominance type, vegetation type, canopy cover class, and tree size class. Where easily identifiable, target a variety of vegetation types and structure classes to capture the representative vegetation communities occurring in the project area.

If you cannot correctly make a determination on all of these calls, complete those that you have confidence in. Make sure the labels are legible and the segment polygons you select represent areas of homogenous vegetation composition, including canopy cover and tree size class. If you cannot adequately identify the segment on the plot map (i.e. heavily forested areas) then record the GPS location so that the precise location can be accurately located and used for the vegetation modeling aspects of the project.

Of particular interest are segment polygons containing homogenous vegetation types that have not been adequately sampled. The crew lead will provide an updated list of these types throughout the field season. Again, any vegetation type collected should be homogenous and should not consist of an inclusion representing only a small proportion or rare occurrence on the landscape.

- Opportunistic Plots

While you are traveling from plot to plot and you identify areas containing vegetation types that have not been adequately sampled, you can establish opportunistic field plot locations and collect vegetation information in the same way as specified for the pre-selected plots. Four principles should guide your selection of opportunistic field plots:

1. Plots will represent vegetation types that are underrepresented, as directed by project personnel.
2. Plots should be located in vegetation types that are homogenous across segment polygons (at least 5 acres in size or 2 acres for riparian and aspen communities).
3. The plot should represent a single vegetation life form and not consist of an inclusion.
4. The plot should not cross roads, major topographic breaks, major streams, etc..

Opportunistic plots **must** be given a completely new number; a previously assigned number cannot be used for an opportunistic plot. Field crews will allocate a set of numbers so that no one will duplicate a number. The individual crew will be responsible for keeping track of their numbers previously used for opportunistic plots.

Initial direction regarding what is considered underrepresented will be given at the start of the project. As field data sheets are received by project personnel, tracking and tallying of both the map units being collected and their distribution will assist with future selection of opportunistic plots. It is the responsibility of field crews to coordinate with Forest Service personnel in the appropriate collection of opportunistic plots, which can be modified as the field data collection progresses.

Data Collection Forms

This section provides information on how to fill out the datasheets.

Field Plot Form

1. Plot ID — Record the 4-digit field plot number.

2. Names of collectors— Record the names of the personnel collecting the data. Initials can be used if they are unique to the entire team. However, names are preferred on the first few forms for each geographic area.

3. Month/Day/Year

4. Level of Observation— Record the level of observation. "VI" stands for visited field plot, "VFD" stands for plot viewed from a distance, "NO" stands for not observable, "MV" stands for moved plots, and "OPP" stands for opportunistic plot.

5. UTM E & N— Record the coordinates for the center of the plot. You should collect a minimum of 30-60 positions for non-forested plots and 60-90 positions for forested plots (or as many as possible if experiencing difficulty). It is important to collect positions **from the plot center**, so be at the center to start collection. Every plot should use a PDOP mask of 6 and elevation mask of 15. If the GPS is not working (low satellites, etc.), then raise the PDOP, using the highest accuracy (i.e. the lowest number) possible. In the Notes section, record changes to PDOP and elevation masks. If using a GPS unit where the PDOP and elevation masks cannot be set, verify a precision of ≤30 feet before collecting positions.

GPS unit should be set to the following projection:

UTM, Zone 12
NAD83
GRS1980

6. Field Photograph— Take a single representative photo of the field site (more can be taken if necessary) and record the digital photo number. Take the photo from a location along the plot perimeter that has a side-hill view toward the plot center to capture the slope of the site. This photo number will need to be completely unique to all photos taken so that when it is transferred it does not get confused with other photos. The photos should be renamed at a later time to match the field plot number and cardinal direction taken (e.g. 1224W). A whiteboard or other marker with the field site number can also be used when taking the photo to help identify the site.

7. Geographic Area— Record the geographic area (GA) that the site is located in. This number should appear on the field plot list and plot map.

8. Ocular Plot Composition— (Estimated from a "Top-down" perspective). Estimate and record the total canopy cover for trees, shrubs, herbaceous, and non-vegetated. Woodland species are included with trees for the ocular plot composition by lifeform. Determine percent canopy cover as if you were looking down on the stand from the air; do not double count overlapping layers that are not viewable from above. For example, smaller sized trees being overlapped by larger ones will be ignored and not counted in the canopy cover estimate. The sum of all life form and non-vegetation type totals must add up to 100%.

List up to the 5 most abundant species and non-vegetation types having ≥5% cover using the PLANTS codes from the Caribou-Targhee species list and non-vegetation type codes from Table 1. Start by listing tree species, then shrubs, herbaceous, and non-vegetated. If the code for any species is not known, its name should be written out and the code looked up later. If a plant can only be identified to the genus level, e.g. due to seasonal condition or disturbance, record only the plant genus and make a note of it on the form. There is one exception where species occurring with less than 5% cover would be recorded. Where the most abundant tree, shrub, and herbaceous species occur with <5% cover, record the most abundant species for each lifeform in order to determine dominance type and corresponding vegetation type map unit.

Table 1. Non-vegetation Type Codes

BARE	Bare soil - soil particles <2mm in diameter
ROCK	Rock >2mm in diameter
LITT	Plant litter and duff, including twigs <1/4 inch in diameter
WOOD	Dead wood material >1/4 inch in diameter, including bases of standing dead trees and shrubs
SNOW	Area covered by permanent ice and/or snow
WATE	Water that obscures other cover types

For each of the listed species/non-vegetation types, estimate and record the percent canopy cover as viewed from above. Record the combined percent cover of all "other" species/non-vegetation types that were not individually listed on the form in the previous step. Cover estimates for each life form/non-vegetation component must sum to the total cover estimates previously recorded. This will allow for making a determination of the vegetation and ground cover types that are occupying the plot without collecting a complete species list.

9. Tree Size Class— (Estimated from a "Top-down" perspective). For forest and woodland sites only (≥10% tree), list out each tree species and cover as recorded in #8. For each species, determine the percent cover of each overstory tree size class and enter it in the size class columns. Determine percent cover of each size class as if you were looking down on the stand from the air; do not double count overlapping layers that are not viewable from above. For example, smaller sized trees that are being overlapped by larger ones will be ignored and not counted in the size class estimate. Total the estimated percent cover for each size class.

Tree size will be determined by estimating diameter at breast height (DBH) for all tree species except those designated woodland species in Table 2. For designated woodland species, tree size will be determined by estimating diameter at root collar (DRC). Instructions for determining DRC for woodland species are found in Appendix A.

Table 2. Caribou-Targhee DRC Measured Woodland Species

JUOS	Juniperus osteosperma	Utah juniper
JUSC2	Juniperus scopulorum	Rocky Mountain juniper
ACGR3	Acer grandidentatum	bigtooth maple
CELE3	Cercocarpus ledifolius	curlleaf mountain mahogany

For the first 5 tree sites, measure DBH or DRC to calibrate subsequent ocular estimates. For every 3-5 plots thereafter (per observer), measure DBH or DRC to maintain consistency of your ocular estimates.

10. Shrub Canopy Cover by line intercept— (Only use if Lifeform is likely to be Shrubland– not for tree sites). List the Plant Codes for each major shrub species. Lay out two 100-foot transects perpendicular to and intersecting the plot center; one running north-south and one running east-west. Estimate and record the number of feet of live canopy cover intercepted for each species within each 10-foot transect increment. Gaps within a single plant, flowers, and flower stalks should be counted as part of the shrub. Total it on the right to get % cover of that species. Total all shrub species percents to get the actual shrub canopy cover for that transect. Calculate the overall shrub canopy cover by averaging the total shrub cover from both the north-south and east-west transects. A measured line intersect should be completed for every 3 to 5 shrubland sites visited to help maintain consistency for the ocular plot composition estimate (#8).

Plot Summary

11. Vegetation Group— Based on the canopy cover from the ocular plot composition (#8) and classification key, determine the vegetation group and record it as the first call ("1st" column). A list of the vegetation groups can be found in Appendix B. If shrub canopy information from transects (#10) has been collected, use the overall shrub transect cover to determine the vegetation group. If the ocular estimate is considered to be more representative of the plot, use the ocular estimate to determine the vegetation group. Include a comment in the notes indicating the ocular estimate was used to make the vegetation group call.

If a plot is near the borderline between vegetation groups, record the secondary group in the "2nd" column. For example, if tree canopy cover totals 12 percent, record Conifer or Deciduous Forest or Woodland as the first call, and Shrubland, Herbaceous, or Non-vegetation as the second call based on the cover of those groups. As another example, if shrub canopy cover totals 12 percent on a plot that is clearly not forest or woodland, record Shrubland as the first call and Herbaceous or Non-vegetation as the second call based on the cover of those groups.

12. Dominance Type— Based on the ocular plot composition (#8) and the dominance classification key, determine the dominance type and record it in the "1st" column. The full dominance type list can be found in the dominance key. For shrubland plots, if shrub canopy information from transects (#10) has been collected, use the shrub species transect cover to determine the dominance type. If the ocular estimate is considered to be more representative of the plot, use the ocular estimate to determine the dominance type. Include a comment in the notes indicating the ocular estimate was used to make the

dominance type call. If a plot is near the borderline between dominance types, record the secondary dominance type in the "2nd" column.
13. Vegetation Type— Based on the dominance type classification, determine the vegetation type and record it in the "1st" column. If a plot is near the borderline between vegetation types, record the secondary type in the "2nd" column based on the secondary dominance type. A list of the vegetation types can be found in Appendix B.

14. Canopy Cover— Based on the predominant vegetation group, determine the canopy cover class for forest, woodland, and shrubland sites and record it in the "1st" column. Upland and riparian forest/woodland should be assigned a forest canopy cover class. Upland, riparian, and alpine shrubland should be assigned a shrubland canopy cover class. A list of the canopy cover classes can be found in Appendix B. For shrubland plots, if shrub canopy information from transects (#10) has been collected, use the overall shrub transect cover to determine the canopy cover class. If the ocular estimate is considered to be more representative of the plot, use the ocular estimate to determine the canopy cover class. Include a comment in the notes indicating the ocular estimate was used to make the canopy cover class call.

If a plot is near the borderline between canopy classes, record the secondary class in the "2nd" column. The secondary canopy class should be based on the secondary vegetation group if it is different from the primary vegetation group.

15. Tree Size Class— Based on the tree size class (#9) determine the most abundant size class and record it in the "1st" column. In case of a tie, record the highest tree size class. A list of the tree size classes can be found in Appendix B. If a plot is near the borderline between classes, record the secondary class in the "2nd" column.

16. Disturbance Event— If there is evidence of a relatively recent disturbance event (fire, timber harvest, insect outbreak, wind event, etc.) within the last 5 years, check the appropriate box and include any relevant information such as whether the site was previously forested, contains standing dead trees, etc. in the notes section.

17:Notes— Record a description of the plot. Include information on the vegetation conditions, disturbances, approximate age of the disturbance, and any other information that is not included in the field form. This description is often the most valuable piece of information we have about a plot and provides details that can have an effect on the mapping process.

Observation Polygon Form

Three additional field observation polygons will be collected for each of the given field plots. Using the image plot maps provided (NAIP imagery, 1-meter resolution), identify a segment polygon representing an area of homogenous vegetation, label it (A, B, C, or D), and fill in the data on the left side of the field form. This data provides general information on the vegetation group, dominance type, vegetation type, canopy closure, and tree size class. Make sure the labels are legible and the segments represent groups of homogenous vegetation, including canopy cover and size class. Only record data you have a high level of confidence in, for example you may need to walk through a polygon in order to determine the dominance type or tree size class. The canopy cover information on the right side of the field form (8-12) will be collected at a later time using photo-interpretation techniques. If you think it would be helpful, designate a symbol on the NAIP plot map to indicate where you were standing when you made the field observation.

1. Vegetation Group— Ocular estimate of dominant vegetation group for the segment polygon you identified on the plot map

2. Dominance Type— Ocular estimate of the dominance type for the segment polygon you identified on the plot map

3. Vegetation Type— Ocular estimate of the vegetation type for the segment polygon you identified on the plot map

4. Canopy Cover— Ocular estimate of the canopy cover class using 5% increments for the segment polygon you identified on the plot map

5. Tree Size Class— Ocular estimate of the tree size class for the segment polygon you identified on the plot map

6. Coordinates— If the segment polygon was difficult to identify on the plot map, and you had to walk into the site to determine the vegetation characteristics, take the center coordinates.

7. Notes— Record any information, such as site description or general vegetation conditions, that may be relevant to the site.

Appendix A.

Diameter at Root Collar (DRC)
(Adapted from Interior West Forest Inventory and Analysis P2 Field Procedures, V5.00)

For species requiring diameter at the root collar, measure the diameter at the ground line or at the stem root collar, whichever is higher. For these trees, treat clumps of stems having a unified crown and common root stock as a single tree; examples include mesquite, juniper, and mountain mahogany. Treat stems of woodland species such as Gambel oak and bigtooth maple as individual trees if they originate below the ground.

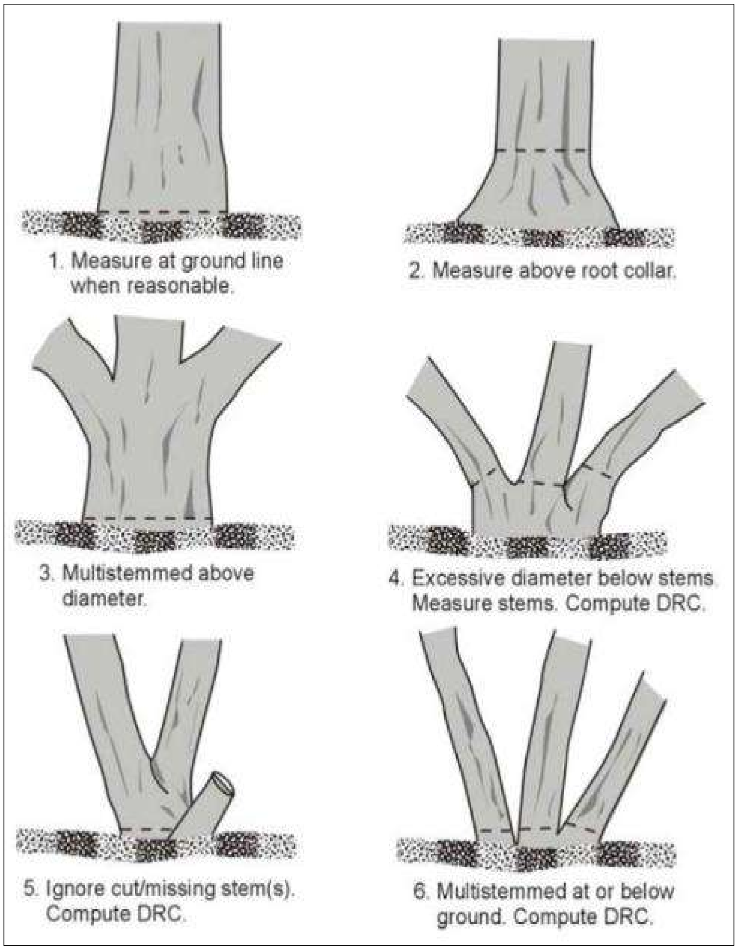
Measuring woodland stem diameters: Before measuring DRC, remove the loose material on the ground (e.g., litter) but not mineral soil. Measure just above any swells present, and in a location so that the diameter measurements are a good representation of the volume in the stems (especially when trees are extremely deformed at the base). Stems must be at least 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point to qualify for measurement. Whenever DRC is impossible or extremely difficult to measure with a diameter tape (e.g., due to thorns, extreme number of limbs), stems may be estimated and recorded to the nearest class. Additional instructions for DRC measurements are illustrated in Figures A and B.

Computing and Recording DRC: For all trees requiring DRC, with at least one stem 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point, DRC is computed as the square root of the sum of the squared stem diameters. For a single-stemmed DRC tree, the computed DRC is equal to the single diameter measured.

Use the following formula to compute DRC:

$DRC = SQRT [SUM (stem\ diameter^2)]$
Round the result to the nearest 0.1 inch. For example, a multi-stemmed woodland tree with stems of 12.2, 13.2, 3.8, and 22.1 would be calculated as:
$DRC = SQRT (12.2^2 + 13.2^2 + 3.8^2 + 22.1^2)$
$= SQRT (825.93)$
$= 28.74$
$= 28.7$

If a previously tallied woodland tree was completely burned and has re-sprouted at the base, treat the previously tallied tree as dead and the new sprouts (1.0-inch DRC and larger) as part of a new tree.



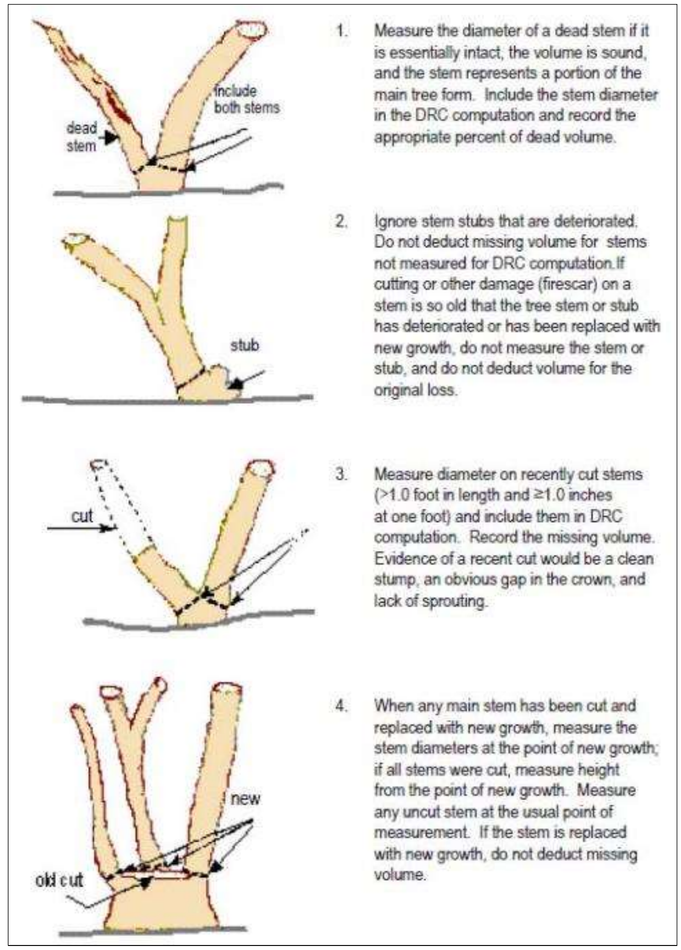


Figure A. How to measure DRC in a variety of situations. The cut stem in example number 5 is < 1 foot in length.

Figure B. Additional examples of how to measure DRC.

Appendix B. Vegetation Group, Vegetation Type, Canopy Cover Class, and Tree Size Class Codes

Vegetation Group	Code
Conifer Forest	**C**
Deciduous Forest	**D**
Shrubland	**S**
Herbaceous	**H**
Riparian	**R**
Alpine	**A**
Sparse Vegetation	**V**
Non-Vegetated	**N**
Woodland	**W**

Vegetation Type	Code
Alpine	
Alpine	**ALP**
Riparian	
Herbaceous Aquatic/flooded Wet Meadows	**HA**
Low Riparian Shrublands	**LRSH**
Mixed Broadleaf Riparian Shrublands	**MBRSH**
Riparian Grasslands & Forblands	**RGRFO**
Willow Riparian Shrublands	**WRSH**
Herbaceous	
Ruderal Grasslands	**RGR**
Tall Forblands	**TF**
Tall Forblands – Ruderal & Xeric	**TFR**
Upland Grasslands and Low Forblands	**GRLFO**
Shrubland	
Low Sagebrush Dwarf Shrublands	**DSE**
Sagebrush Dry Shrublands	**SSD**
Sagebrush/Antelope Bitterbrush Shrublands	**SB**
Upland Forest Shrublands	**FSH**
Upland Mountain Shrublands	**MSH**
Forest and Woodland	
Aspen	**AS**
Aspen/Douglas-fir	**AS/DF**
Aspen/Lodgepole Pine	**AS/LP**
Aspen/Spruce/ Fir	**AS/SF**

Vegetation Type	**Code**
Aspen/Woodland	**AS/W**
Bigtooth Maple	**MP**
Bigtooth Maple/Conifer	**MP/C**
Douglas-fir	**DF**
Douglas-fir Mix	**DFmix**
Douglas-fir/Aspen	**DF/AS**
Douglas-fir/Limber Pine	**DF/LM**
Douglas-fir/Woodland	**DF/W**
Juniper	**J**
Juniper/Conifer	**J/C**
Limber Pine	**LM**
Limber Pine/Douglas-fir	**LM/DF**
Lodgepole Mix	**LPmix**
Lodgepole Pine	**LP**
Lodgepole Pine/Aspen	**LP/AS**
Mahogany	**MH**
Mahogany/Conifer	**MH/C**
Mahogany/Juniper	**MH/J**
Ponderosa Pine	**PP**
Riparian Forest Woodland	**RFW**
Spruce/Fir Mix	**SFmix**
Spruce/Fir/Aspen	**SF/AS**
Spruce/Fir/Whitebark	**SF/WB**
Spruce/Fir	**SF**
Whitebark Pine	**WB**
Whitebark Pine/Spruce/ Fir	**WB/SF**
Sparse Vegetation	
Sparse Vegetation	**SV**
Other	
Agriculture	**AGR**
Developed	**DEV**
Barren/Rock	**BR**
Water	**WA**
Unknown	**UNK**

Tree Canopy Cover Class	Code
10 - 29%	TC1
30 - 49%	TC2
50 - 59%	TC3
60 - 69%	TC4
≥ 70%	TC5

Shrub Canopy Cover Class	Code
10 - 14%	SC1
15 - 24%	SC2
25 - 49%	SC3
≥ 50%	SC4

Tree Size Class	Code
< 4.5 feet tall	TS1
0 - 0.9"	TS2
1 - 4.9"	TS3
5 - 6.9"	TS4
7 - 9.9"	TS5
10 - 15.9"	TS6
16 - 19.9"	TS7
20 - 29.9"	TS8
≥ 30"	TS9

Region 4 - Caribou-Targhee NF - FIELD PLOT FORM v5/27/2011

1- PlotID# ____________ 2- Names: ______________________________ 3- M/D/YY ___-___-___

4- Level of Observation: VI VFD NO MV OPP

5- UTM E: ______________________ N: ________________________ (UTM, NAD83, GRS1980, Zone 12)

6- Field Photograph: ________________________ 7- Geographic Area: 1 2 3 4 5

8- "OCULAR" Plot Composition

Tree	Cover	Shrub	Cover	Herbaceous	Cover	Non-veg	Cover
Other		Other		Other		Other	
Total		Total		Total		Total	
						Lifeform & Non-Veg totals must add up to 100%	

9- Tree DBH or DRC Size Class

Plant Code	Cover	TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	TS9
Other										
Total										

Tree Size Classes	
TS1	<4.5 feet tall
TS2	0 - 0.9"
TS3	1 - 4.9"
TS4	5 - 6.9"
TS5	7 - 9.9"
TS6	10 - 15.9"
TS7	16 - 19.9"
TS8	20 - 29.9"
TS9	≥ 30"

10- Shrub Canopy Cover - by line intercept

Transect North/South

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	50-60'	60-70'	70-80'	80-90'	90-100'	Total
Other											
								Total N/S Shrub CC			

Transect East/West

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	50-60'	60-70'	70-80'	80-90'	90-100'	Total
Other											
								Total E/W Shrub CC			
								Overall Shrub CC			

PLOT SUMMARY

	1st	2nd
11- Veg Group		
12- Dom Type		
13- Veg Type		
14- Cnpy Cover		
15- Tree Size		

16- Disturbance Event: ☐ Burn ☐ Harvest ☐ Other

17- Notes:

17- Notes (cont.):

OBSERVATION POLYGON FORM

Field Observation | PI Canopy Cover

Polygon |A|
1-Veg Group |______________| 7-Notes:
2-Dom Type |______________|
3-Veg Type |______________|
4-Cnpy Cover |______________|
5-Tree Size |______________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Polygon |B|
1-Veg Group |______________| 7-Notes:
2-Dom Type |______________|
3-Veg Type |______________|
4-Cnpy Cover |______________|
5-Tree Size |______________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Polygon |C|
1-Veg Group |______________| 7-Notes:
2-Dom Type |______________|
3-Veg Type |______________|
4-Cnpy Cover |______________|
5-Tree Size |______________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Polygon |D|
1-Veg Group |______________| 7-Notes:
2-Dom Type |______________|
3-Veg Type |______________|
4-Cnpy Cover |______________|
5-Tree Size |______________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Tree Cover Classes:

TC1	10 - 29%
TC2	30 - 49%
TC3	50 - 59%
TC4	60 - 69%
TC5	≥ 70%

Shrub Cover Classes:

SC1	10 - 14%
SC2	15 - 24%
SC3	25 - 49%
SC4	≥ 50%

Appendix VII: Aerial Photo Interpretation Guide

Caribou-Targhee National Forest
Existing Vegetation Mapping Project
Aerial Photo Interpretation Guide
2/15/2012

1. **Introduction**

This guide outlines the procedures for conducting aerial photo interpretation (PI) for the Caribou-Targhee National Forest Existing Vegetation Mapping Project. An integrated approach combining field experience, field sampled data, and orthophoto interpretation will be used to characterize vegetation composition and structure from the 2009 digital resource and other available aerial imagery. The resulting photo-based information will validate and supplement field-based data for modeling and mapping the distribution and extent of existing (current) vegetation.

2. **Background**

In 2011, a sample design was developed for the collection of field-based training reference data. Approximately 1,000 *field plots* were proportionally distributed within the feature space of a spectral-topographic landscape stratification. Each 1/18 acre circular plot (50' radius) was visited by field crews to collect information on existing vegetation. In addition to the field plots, crews collected vegetation summary data for about 3,000 *observation polygons* (~3 observations per field plot). *Field plots* and *observation polygons* are referred to collectively in this guide as *sites*.

A continuous set of image segments were generated across the project area using an automated process that delineates landscape patterns into spectrally and topographically homogenous areas using a combination of geospatial data layers including digital aerial photography, satellite imagery, and elevation data derivatives. Each field plot is located within an individual segment, and each observation polygon is comprised of a segment independent of a field plot (Figure 1). Photo interpretation for this project will be conducted across the full extent of a given segment. Because segments will be used as the modeling unit in the mapping process, it is essential that the attributes identified for vegetation type, canopy cover, and tree size class represent the entire segment. Photo interpretation allows for the broader view necessary to assess a larger vegetation patch or stand than what is feasible in the field.

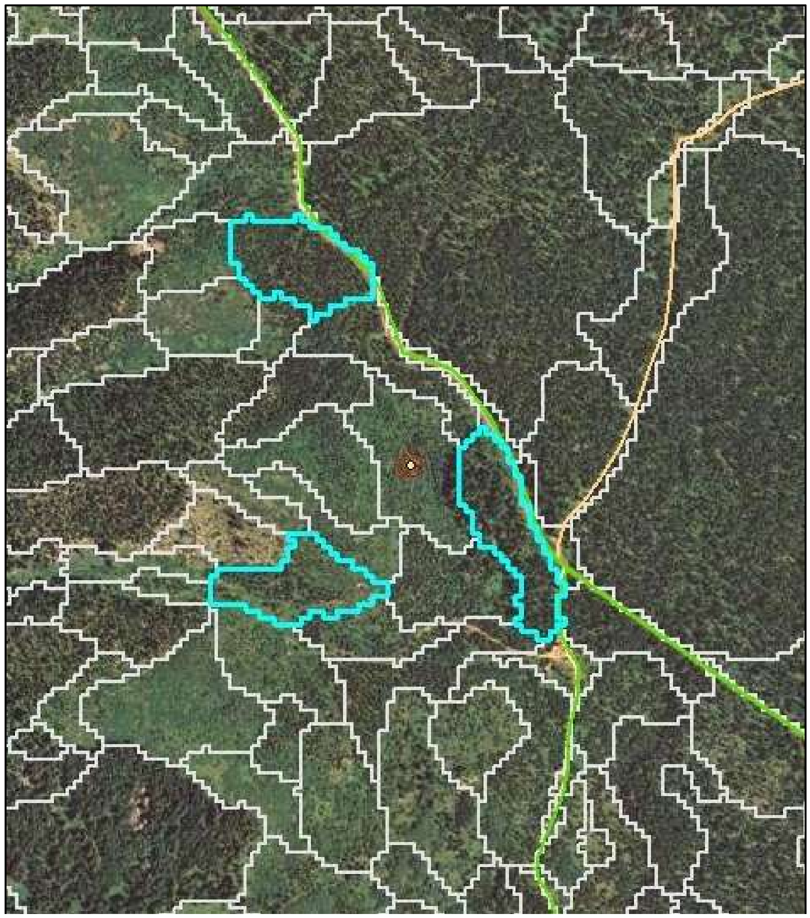


Figure 1. Segments displayed over high resolution aerial imagery. The red circle depicts a 50’ radius field plot within an individual segment. The blue segments highlight three field-selected observation polygons.

The PI process consists of the following three interpretation components, also outlined in the workflow in Appendix A.

- Formation homogeneity
- Forested canopy cover class
- Field data representativeness

The *formation homogeneity* interpretation involves identifying whether the segment represents a homogenous vegetation formation. First, the formation of the segment is determined according to the *R4 Key to Vegetation Formations*, based on percent canopy cover as viewed from above. The percent coverage scales in Appendix B are used to guide canopy cover estimations for identifying the appropriate vegetation formation. Homogeneity of the segment is then determined based on the uniformity of the identified vegetation formation across the majority of the segment. Appendix C contains example segments and corresponding homogeneity determinations.

The *forested canopy cover class* interpretation consists of estimating the tree canopy cover class for segments identified as forested. As completed in the *formation homogeneity* interpretation procedures above, the *R4 Key to Vegetation Formations* and percent coverage scales are used to identify whether the segment is a Forest/Woodland vegetation formation based on an ocular estimate of total percent tree cover as viewed from above. The appropriate tree canopy cover class is then recorded for segments identified as Forest/Woodland formation. Appendix D contains example segments and corresponding canopy cover class determinations.

Finally, the *field data representativeness* interpretation consists of identifying whether the field data-assigned attribute for vegetation group, vegetation type, and tree size class (as applicable) reasonably represents the majority of the segment. Together with the *formation homogeneity* interpretation, this allows for assessing the suitability of each segment for use as training reference data in the modeling and mapping process.

3. **Photo Interpretation Guide**

3.1. <u>Session Setup</u>

3.1.1. Aerial Imagery – The following three alternative sources of aerial imagery data sets are accessed for display in ArcMap.

- *Resource Imagery* - 2009, 0.5 meter, 4-band. Access the imagery in ArcMap by clicking on the Add Image Server Connection button, then navigate to and add:

  166.2.126.235/Imagery/Half-Meter/Region4/Caribou_Targhee_NF_4_Band

  The default display is in natural color. To view the imagery in color infrared which can be advantageous for interpreting vegetation characteristics, left click the color box symbol for each band in the ArcMap Table of Contents and reassign each to the following bands: Red to Band_4, Green to Band_1, and Blue to Band_2.

- *NAIP Imagery* – 2011, 1 meter, 4-band. This imagery is used to supplement the 0.5-meter resource imagery. Use the NAIP imagery for interpreting segments where a landscape disturbance event, e.g. a burn or other natural or man-caused disturbance has impacted the segment since the 2009 imagery was acquired. This image data set can also be used as an alternative image source when it might be too difficult to compensate interpretations for excessive tree lean due to off-nadir view angles or extreme shadowing due to relatively low sun angles. Access the imagery by adding the following Image Server connection:

  166.2.126.235/ Imagery/1_Meter/Region_4/Idaho_NAIP_2011

- *Bing Imagery* – sub-meter 3-band. Use as an additional alternative image data source. Access the imagery using the ArcMap Add Data button drop down menu, select Add Basemap, then double-click Imagery.

Prior to conducting photo interpretation for each segment, display and review the resource, NAIP, and Bing imagery to determine which data set is best suited for some or all interpretations.

3.1.2. Segments - A GIS layer containing the segment polygons to be photo interpreted is provided in the working directory of each interpreter on the T drive. The attribute table for the layer includes a record for each segment containing the following field-collected attributes: vegetation group, vegetation type, canopy cover class, and tree size class (as applicable).

3.1.3. Ten percent circular polygon layer – A GIS layer containing circular polygons representing ten percent of the area of each segment is provided in the working directory of each interpreter on the T drive. This layer is used to aid in estimating percent tree cover in 10% increments and is particularly useful for interpreting whether the segment contains the minimum 10% tree canopy cover required to meet the definition of a forested segment.

3.2. <u>Formation Homogeneity</u>

3.2.1. Vegetation Formation – Using the *R4 Key to Vegetation Formations*, ocularly estimate the dominant vegetation formation across the entire segment based on canopy cover as viewed from directly above. For the purpose of PI, the Grassland and Forbland formations are combined into a single Herbaceous category. Color infrared composite imagery is particularly useful for distinguishing herbaceous cover. Refer to the coverage scale in Appendix B, the ten percent circular polygon layer, and the poster canopy cover examples as a guide to estimating cover (Appendix D).

- Forest/Woodland
- Shrubland
- Herbaceous
- Non-vegetated

3.2.2. Formation Homogeneity – After determining the vegetation formation, estimate and record whether the formation is uniform across the majority of the segment. Refer to the example segments in Appendix C to aid in assessing homogeneity.

3.2.3. If it is found that the segment is not homogenous, skip the remaining steps below and proceed to the next segment. If the segment is determined to be homogenous, continue to step 3.3.1.

3.3. <u>Forested Canopy Cover Class</u>

3.3.1. Forested Segment – If the vegetation formation for the segment is identified as Forest/Woodland in 3.2.1. above, continue to the next step. If the formation for the segment is not Forest/Woodland, skip to step 3.4.2. Vegetation Group.

3.3.2. Canopy Cover Class – For a segment identified as Forest/Woodland, determine and record the appropriate tree canopy cover class based on an ocular estimate of total percent tree cover as viewed from directly above. Again, refer to the coverage scale in Appendix B, the ten percent circular polygon layer, and the poster canopy cover examples as a guide for estimating cover (Appendix D). Tree canopy cover classes include:

- TC1: 10 - 29%
- TC2: 30 - 49%
- TC3: 50 - 59%
- TC4: 60 - 69%
- TC5: ≥ 70%

3.3.3. If the percent canopy cover results within the segment are near the borderline between cover classes, record a secondary canopy cover class call.

3.4. <u>Field Data Representativeness</u>

3.4.1. Tree Size Class – If the vegetation formation for the segment is identified as Forest/Woodland 3.2.1., estimate whether the field-determined tree size call reasonably represents the most abundant tree size class. Estimate the most abundant tree size class within the full extent of the segment based on canopy cover as viewed from directly above, regardless of spatial distribution.

Tree size is represented using diameter at breast height (DBH) for all tree species except the designated woodland species listed in Table 1. For woodland species, tree size represents diameter at root collar (DRC). Tree size classes include:

- TS1: < 4.5 feet tall
- TS2: 0 - 4.9”
- TS3: 5 - 9.9”
- TS4: 10 - 19.9”
- TS5: 20 - 29.9”
- TS6: ≥ 30”

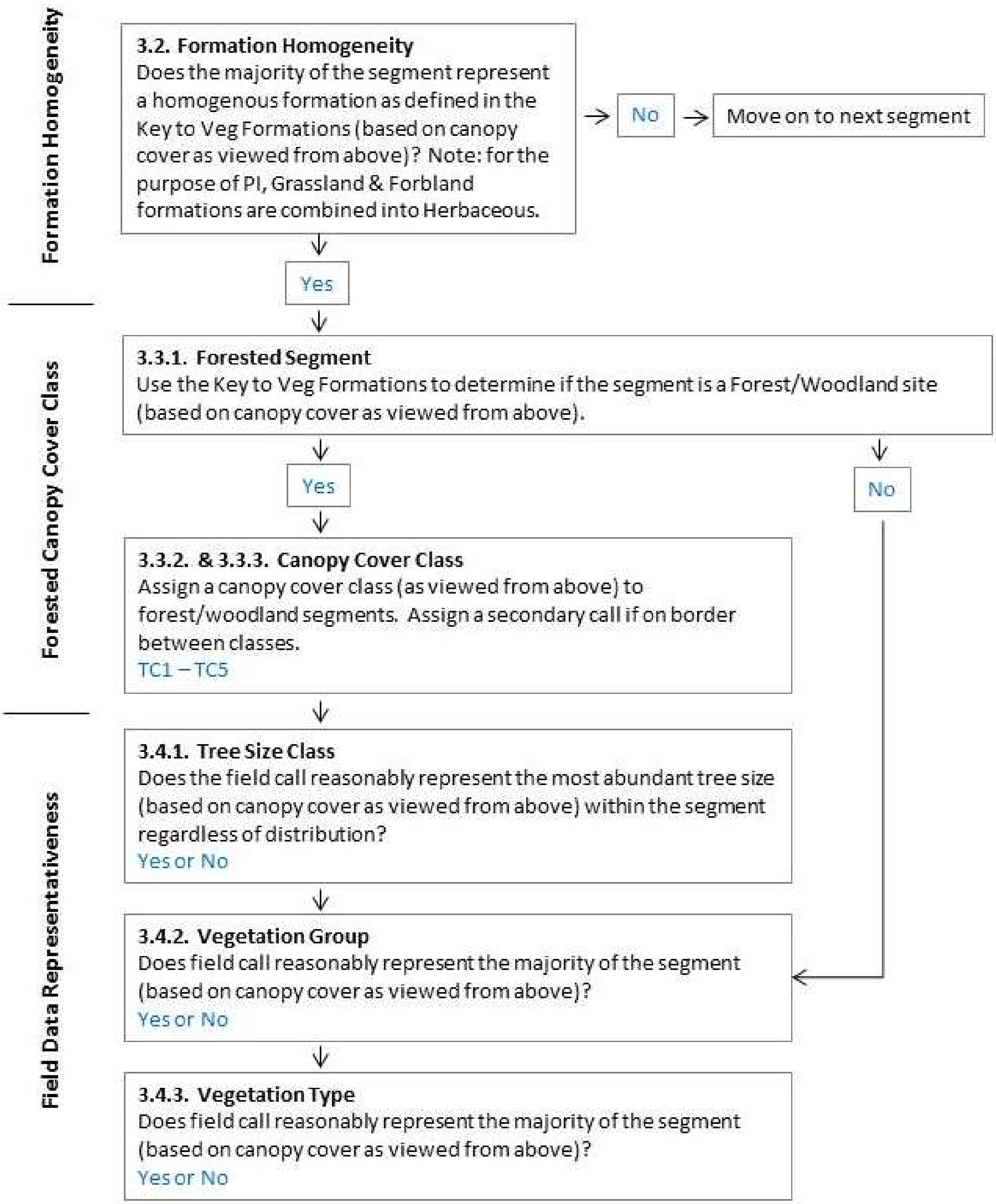
Table 1. Caribou-Targhee DRC Measured Woodland Species

JUOS	Juniperus osteosperma	Utah juniper
JUSC2	Juniperus scopulorum	Rocky Mountain juniper
ACGR3	Acer grandidentatum	bigtooth maple
CELE3	Cercocarpus ledifolius	curlleaf mountain mahogany

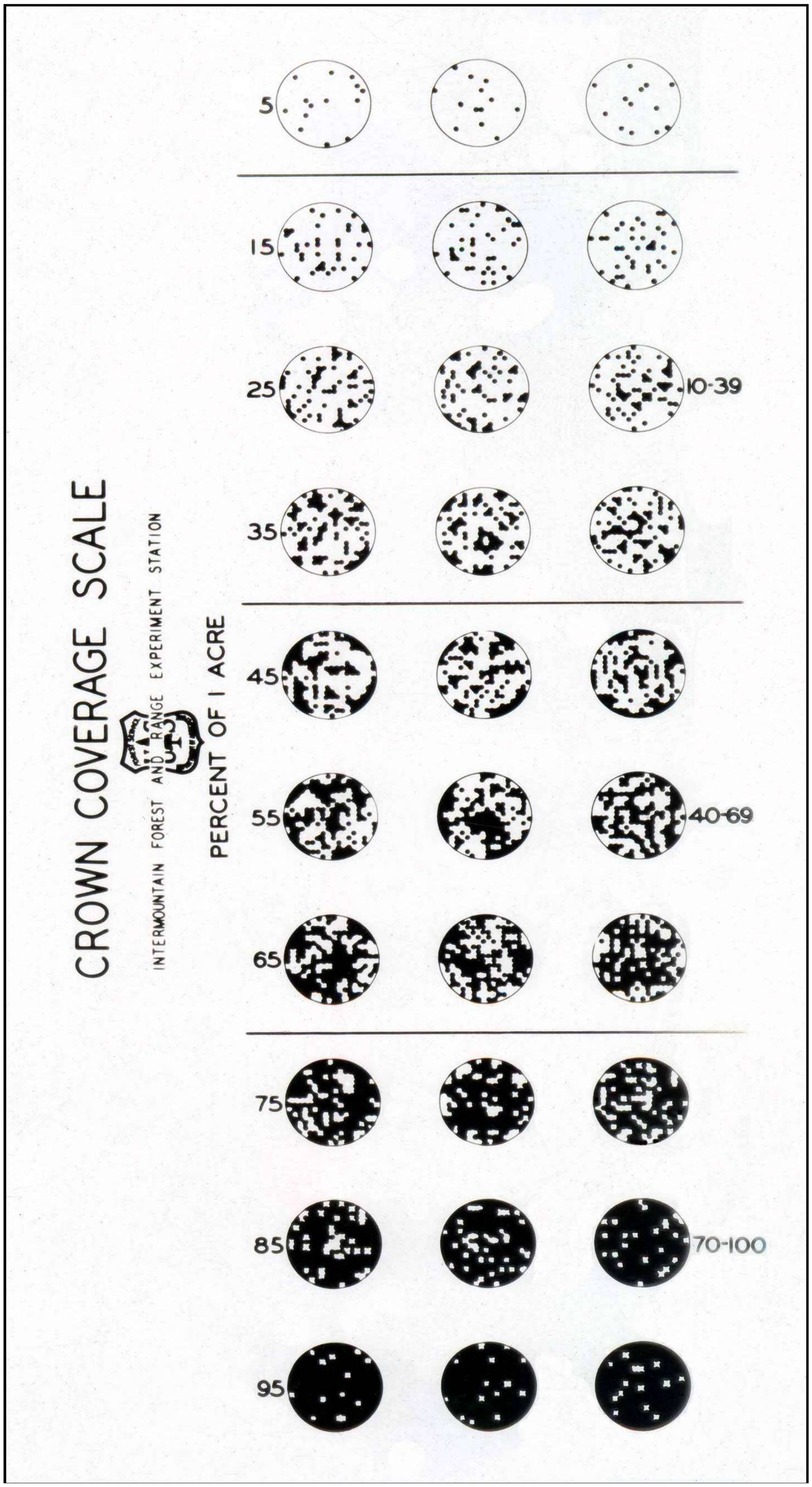
3.4.2. Vegetation Group - Using the *Caribou-Targhee Existing Vegetation Keys*, estimate whether the field-determined vegetation group call reasonably represents the vegetation group across the segment. Estimate the vegetation group based on canopy cover as viewed from directly above, regardless of spatial distribution. Refer to the coverage scales, the 10% circular polygon layer, and poster examples as a guide to estimating percent cover.

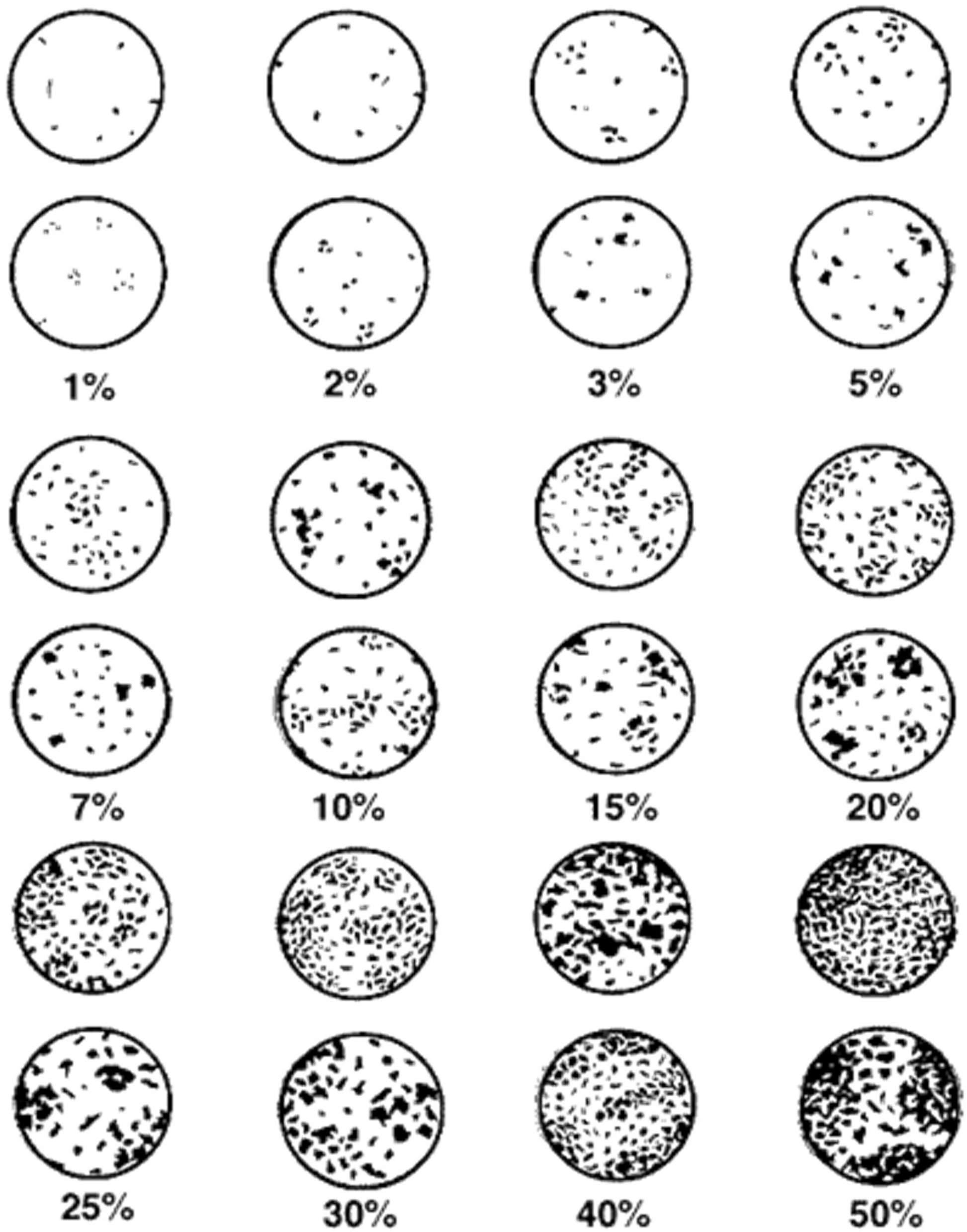
3.4.3. Vegetation Type - Using the *Caribou-Targhee Existing Vegetation Keys*, estimate whether the field-determined vegetation type call reasonably represents the vegetation type across the segment. Estimate the vegetation group based on canopy cover as viewed from directly above, regardless of spatial distribution. Again, refer to the coverage scales, the 10% circular polygon layer, and poster examples as a guide to estimating percent cover.

Appendix A – Photo Interpretation Workflow



Appendix B – Canopy Coverage Scales

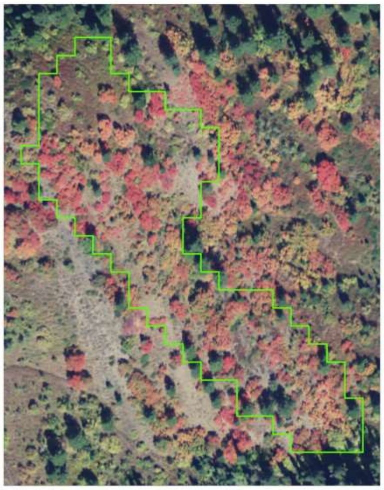


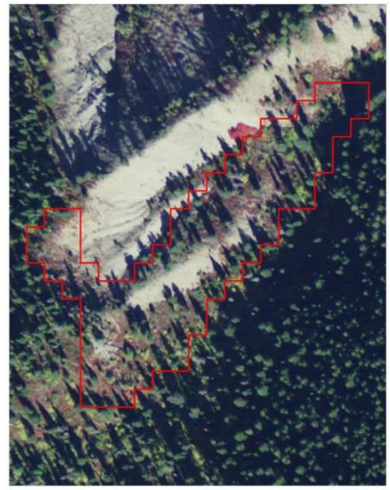


From the Integrated Land Management Bureau of British Columbia website.

Appendix C – Formation Homogeneity Examples

Yes **No**

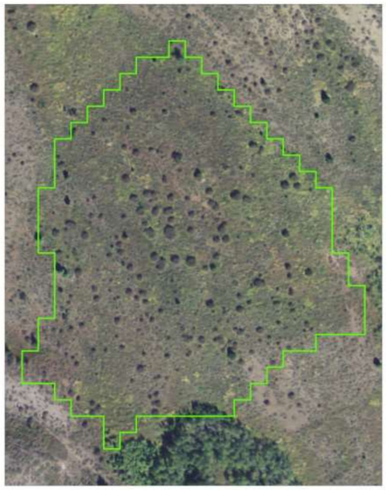




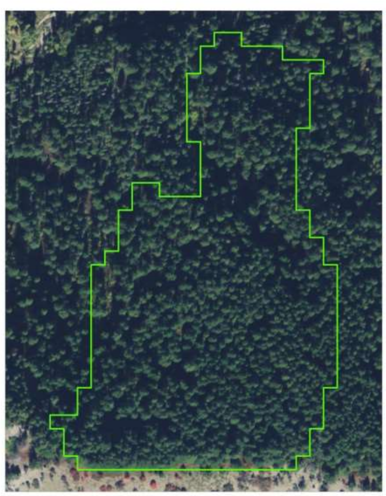
Pair 1: Medium canopy cover deciduous forest with a relatively even distribution across the landscape (*left*). Patchy, mixed forest with substantial non-forest gaps characterized by rock and shrub (*right*).

Pair 2: Low canopy cover conifer forest that is distributed evenly enough to be considered to have adequate homogeneity (*left*). Non-uniform vegetation cover with areas of shrub, non-forest, and large trees contained within the same polygon (*right*).

Yes **No**

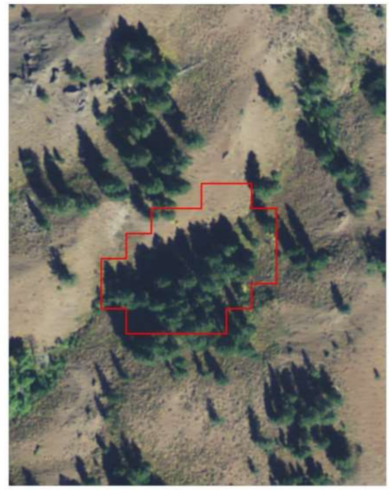



Pair 3: Homogeneous, open, xeric shrubland with tree canopy < 10% (*left*). Convoluted polygon containing strips of forest and non-forest (*right*).

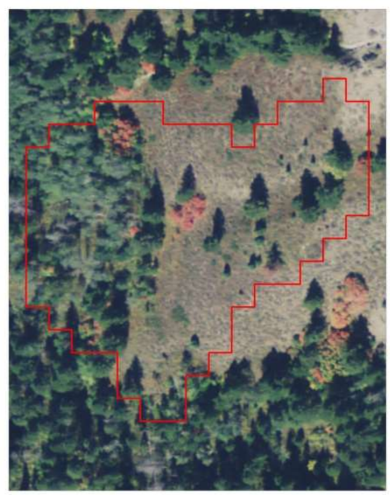



Pair 4: Heavily forested polygon with consistent cover and no obvious changes of life form (*left*). Polygon that might meet the 10% tree canopy cover requirement but contains non-forest shrubland, developed structures and roads that make it a poor training site (*right*).

Yes No

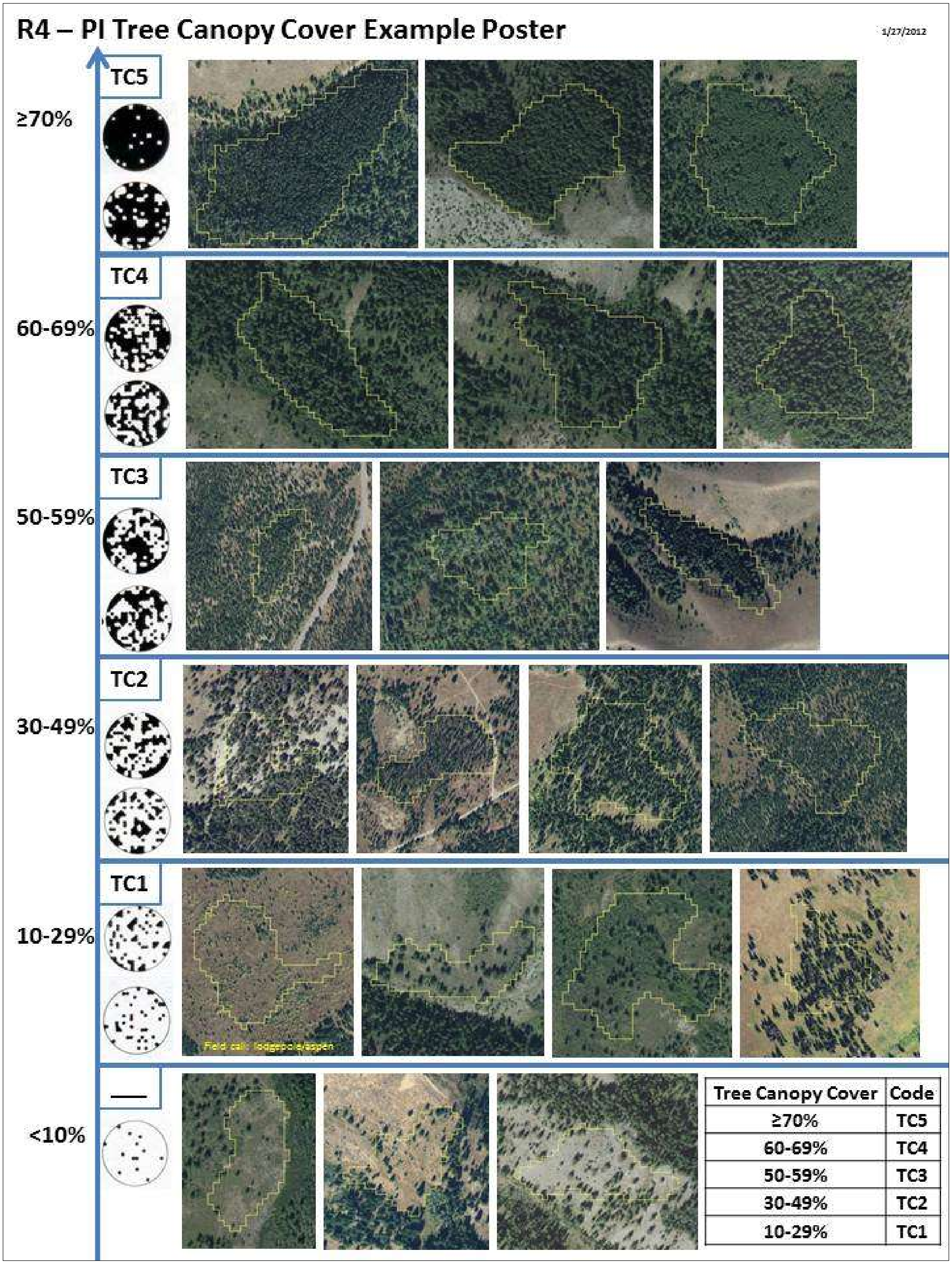


Pair 5: Mixed conifer/deciduous forest with relatively even distribution (*left*). Polygon containing distinct forest on one half and distinct non-forest on the other with an abrupt boundary in between (*right*).



Pair 6: Mixed forest patch with a relatively uniform distribution across the polygon (*left*). Mixed forest with a distinct transition to non-forest within the same polygon (*right*).

Appendix D – Canopy Cover Poster (also printed as large poster)



Appendix VIII: Tree Size Class Modeling Data Layers

Data layers used in the modeling of tree size class for the Caribou-Targhee National Forest Service

Data Source	# of Layers	Spatial Resolution	Description	Statistics Used	Total # of Predictors
Landsat 5 summer mosaic	6	30m	Used R, G, B, NIR, MIR, & NIR2 bands	Mean and Standard Deviation	12
VCT	2	30m	Vegetation Change Tracker algorithm to detect disturbance- used both a thematic and continuous output	Majority, Mean, and Standard Deviation	3
IfSAR	1	5m	Radar-based delta change product to detect canopy height	Maximum and Mean	2
NAIP NDVI	1	10m	NDVI derived from resampled 1m NAIP imagery	Mean and Standard Deviation	2
DEM	1	10m	Raw 10m digital elevation data	Mean and Standard Deviation	2
Heat load	1	10m	To predict direct solar radiation trigonometric functions of slope, aspect, and latitude were used	Mean and Standard Deviation	2
Vegetation type map	1	10m	The existing vegetation map was used given that certain dominance types are associated with larger tree diameters	Majority	1

Appendix IX: Existing Vegetation Mapping Draft Review

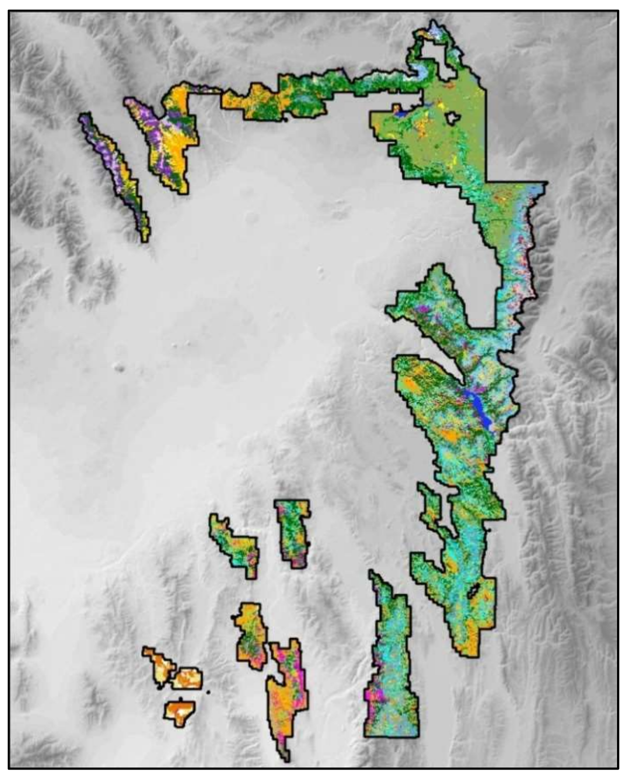
CARIBOU-TARGHEE NATIONAL FOREST
EXISTING VEGETATION MAPPING DRAFT MAP REVIEW
July 17- August 6 2012

Background:

The Remote Sensing Applications Center (RSAC) was tasked by the Caribou-Targhee National Forest to develop a set of mid-level existing vegetation maps. Existing vegetation is the plant cover, or floristic composition and vegetation structure, occurring at a given location at the current time (Brohman and Bryant 2005). This should not be confused with Potential Natural Vegetation (PNV) which describes the vegetation communities that would be established if all successional sequences were completed without interference by man under the present climatic and edaphic conditions (Tuxen 1956). The final map products for this project will include existing vegetation type, canopy cover, and tree size class.

The project has utilized remote sensing techniques and field data to map existing vegetation types. During this process, RSAC has worked with the Forests and the Regional Office to collect and develop the data layers required to implement various semi-automated remote sensing techniques. High resolution aerial imagery collected in 2009 was used to create “mapping segments" (GIS polygons) from a combination of spectral information and physical characteristics of the landscape. These segments were then assigned a vegetation type using an ensemble classifier. The vegetation types on the draft maps have been aggregated to the final map unit sizes of 2 acres for riparian types and 5 acres for upland types. The final maps will be produced at a 1:100,000 scale.

This review will focus on the draft vegetation type maps only (figure 1). Meetings scheduled at the Soda Springs and Ashton Ranger District offices are planned to solicit feedback from knowledgeable staff members who can evaluate the maps and help improve the depiction of existing vegetation on the final maps. Map revisions will be based almost entirely on the information provided from the review process. Digital maps are available via Image Server or Webmap. Hardcopy maps were also produced for each ranger district at scales ranging from 50,000 to 170,000.



Vegetation type map units:

Not all vegetation types have been mapped in each district. The reference sites were reviewed at the beginning of the modeling process and the vegetation types to be depicted on the draft map were finalized. A list of the vegetation type map units and acres of each type in each district are shown on the following page.

		Caribou-Targhee NF Ranger Districts - Acres									
	Vegetation Types	Dubois	Ashton/Island Park	Teton Basin	Palisades	Soda Springs	Montpelier	WestSide	Curlew	TOTAL ACRES	TOTAL %
1	Aspen	0	22,223	21,509	42,565	63,035	56,713	35,318	0	241,364	8%
2	Aspen/Conifer	0	12,705	13,234	22,651	19,327	13,529	513	0	81,960	3%
3	Conifer/Aspen	10,003	24,541	9,691	12,639	18,906	27,313	6,029	0	109,123	4%
4	Douglas-fir	139,328	79,365	40,838	136,284	85,325	66,206	53,005	0	600,351	20%
5	Douglas-fir/Lodgepole	4,885	28,594	2,531	3,487	3,512	0	0	0	43,009	1%
6	Limber Pine/Douglas-fir	51,610	2,218	0	0	0	0	0	0	53,828	2%
7	Lodgepole Pine	1,024	350,112	41,114	11,844	27,008	47,033	1,125	0	479,259	16%
8	Spruce/Fir	4,225	18,696	37,193	43,477	5,108	13,361	604	0	122,663	4%
9	Spruce/Fir Mix	16,334	49,149	34,055	29,226	41,233	58,856	2,122	0	230,977	8%
10	Whitebark mix	995	7,726	15,509	1,421	0	0	0	0	25,650	1%
11	Bigtooth Maple mix	0	106	3,658	26,388	5,068	18,476	37,920	0	91,615	3%
12	Juniper mix	410	6	64	8,644	94	368	23,994	89	33,669	1%
13	Mountain Mahagony Mix	10,768	190	288	11,424	1,538	15,691	21,028	0	60,928	2%
14	Forest & Mountain Shrublands	26	289	2,513	15,987	18,402	10,864	21,715	0	69,796	2%
15	Dwarf Sagebrush	24,563	0	0	0	233	1,844	8,487	0	35,127	1%
16	Mountain Big Sagebrush	122,733	27,211	16,027	64,048	64,850	86,873	112,237	0	493,981	16%
17	WY, Basin, & Bonneville Sage	93	0	0	0	6	75	6,515	35,791	42,480	1%
18	Alpine Herbaceous	3,067	1,831	11,812	387	7	0	0	0	17,103	1%
19	Subalpine Herbaceous	22,427	8,411	0	0	0	0	0	0	30,838	1%
20	Montane Herbaceous	13,996	13,789	4,382	11,578	4,077	6,702	6,744	0	61,269	2%
21	Ruderal Grasslands	0	6	0	0	0	0	0	24,600	24,606	1%
22	Riparian Herbaceous	334	2,766	0	0	633	1,053	376	222	5,384	0%
23	Riparian Shrublands/Dec Tree	4,605	7,594	581	5,059	3,810	1,542	904	549	24,645	1%
24	Barren/Sparsely Vegetated	21,900	2,901	12,615	10,908	667	581	95	0	49,667	2%
25	Agriculture		35	75	822	198	0	1,959	13,619	16,709	1%
26	Developed		1,747	147	1,034	2,132	772	693	0	6,524	0%
27	Water		8,202	32	12,879	0	67	51	156	21,387	1%
TOTAL ACRES		453,328	670,412	267,869	472,750	365,171	427,919	341,434	75,026	**3,073,911**	

Review Process:

For the review, provide as much information about the draft map as possible. You have been provided with both digital and hardcopy draft maps. Either form of review is acceptable… Overall, it is important to focus your attention on the general vegetation patterns and distribution of vegetation types. We need information on what is correct and what is incorrect. Please remember this is a mid-level map (1:100,000 scale) and not a site map. The minimum size of an area that will be depicted on the final map is 5 acres for upland types and 2 acres for riparian types. This is not project level mapping; fine scaled vegetation patches or stands will not be represented on the final map.

For either the hard copy or digital map review you must follow the "Caribou-Targhee Vegetation Key" when determining the vegetation type map unit. This ensures that everyone is assigning types based on the same rules and descriptions.

In general, the draft map review process includes the following phases:

Review the entire district you work on. Focus on general vegetation distribution and patterns and determine if the overall community types that you see are represented.

Next focus on specific areas that you are most familiar with. These include areas that you have done more detailed project work on or localized studies.

If necessary follow up with field visits to areas that are confused and correct labels cannot be easily determined.

Also review the forest and district proportion summaries provided in this procedure.

The next sections provide a description of reviewing both hardcopy and digital maps.

<u>Hardcopy paper draft map review procedures:</u>

Write notes, circle areas of concern, and document any other information on the hardcopy maps and the fill in the review form provided. Enter the map letter identified from the upper right corner of the map and the quad name on the form. Label each area marked on the map with a unique ID (number, letter, or combination) that corresponds to the comments entered on the form. It is also important to include your name on the form to allow the mapping specialists to follow up with any questions and/or further discussion. A digital version of the form as an Excel spreadsheet is also provided.

<u>Digital draft map review procedures:</u>

Digital versions of the draft map are available through Image Server and webmap. It is important to review the general distribution and extent of vegetation patterns at a scale that corresponds to the midlevel mapping scale, e.g. 1:50,000 to 1:100,000. To access the map layers using Image Server or webmap use the following directions.

Image Server instructions:

1. Open a new session of ArcMap
2. To add image server:

a. Go to Tools → Customize
b. Select the Commands Tab
c. Search for Image Server
d. Add Image Server Connection

3. Open the Image Server Connection. Enter 166.2.126.226 for the Sever Name.
4. Select “Maps”→ Select “Region_4” → Select “ID_Caribou_Targheee_Midlevel_Draft_VMap_ThematicRaster_RGB_2012” and click on Finish.

Webmap instructions:

1. Open webmap. Go to: http://166.2.126.175/CTdraftreview/
2. A web browser will open and the map will be displayed automatically. There are four buttons at the top of the screen, just to the right of center. These buttons from left to right are: Table of Contents (on/off, adjust transparency of any layer), static veg map legend, editing widget, misc tools. The legend can be activated and deactivated by clicking on legend icon.
3. Making Edits to the map. Use the editing widget to draw polygons for areas where changes need to be made or where you see the map not following the pattern of the landscape. To begin making edits click on the editing widget. An Edit window will open. Select the map unit class you wish to place on the map. Select a drawing tool (in the lower right of the edit window) and begin digitizing on the map. After the edit is complete, an attribute box will appear. Here you will enter your name for edit tracking. Full polygon editing is available for point to point and freehand. The lower left of the editing window has tools to make selections for deleting edit features if needed.
4. Saving edits to the map. Your changes will be automatically saved to the server at RSAC when you close the webmap session.

Additional notes on using webmap:

- Toolbar buttons from left to right:
  - Table of contents: Use the slider underneath each layer to adjust the transparency.
  - Static legend: Toggle the map legend on and off. The legend currently has a bug. Once the legend is turned on, you can't turn it off w/o refreshing the webpage. This is a work in progress and will be fixed soon.
  - Editing Tools: This opens the editing interface.
  - Additional tools: Similar to tools in ArcMap, there is identify, find places, draw/measure, profile an elevation, export jpg (scrncap), and print tools.
- Three different backgrounds are available to view as reference (imagery, streets, and topo). These will all change to higher resolutions as you zoom in.
- Navigation tools are on the left of map. Additionally you can use keyboard arrows, mouse panning with click and drag, and the scroll wheel on the mouse to zoom
- Lower right corner of map has an overview pop out tool as well as a full screen mode. It should be noted the keyboard cannot be used when viewing in full screen.

District Questions:

This section provides more specific questions for each district.

<u>Dubois Ranger District:</u>

- Added in Juniper Mix to the Cedar Canyon area?
- Have a lot of Limber Pine in the western edge of the district, in the Lemhi Range and Beaverhead Mountains. No Whitebark Pine occurs. Is this OK?
- The eastern side is mostly Douglas-fir, Douglas-fir/Lodgepole Pine mix and Spruce/Fir mix.

<u>Ashton/Island Park Ranger District:</u>

- The reference sites for the area were heavily weighted toward LP across the District (Generally between Island Park Reservoir and YellowstoneNP). Is this an accurate representation of what is on the ground?
- What species are used to stock harvest areas? Is it all Lodgepole Pine? Is this different from what naturally restocks?
- Are the former wetlands and perennial lakes and ponds under transition to a statically xeric herbaceous dominance type vegetation or are they undergoing state-transition continually? Much of the region is experiencing a drying –many former wetlands or even ponds and small lakes map as a Mountain Herbaceous dominance type- is a this transitional stage for the vegetation type or is there a stasis in what these former wetlands are changing to?

<u>Teton Basin Ranger District:</u>

- Harvest areas in the northern part of the district are being labeled as Lodgepole Pine and Spruce/Fir?
- Do the alpine areas look reasonable? Especially the Whitebark Pine and Alpine vegetation types. There are some areas that Bigtooth Maple seems to be too high in elevation?

<u>Palisades Ranger District:</u>

- Mapped some areas Whitebark Pine – in the Powder Peak area, Palisades Peak & Little Palisades Peak, and Sheep Mtn. Are these OK?
- Most of the forested areas are Spruce/Fir and Douglas-Fir types?
- Do Juniper mix and Mountain Mahogany mix type look OK – along the western edge on the Snake River, going up Pine Creek, and the Baldy Canyon area?
- Most of the sagebrush areas are classified as Mountain Big. Almost nothing is mapped as Wyoming Big, Basin Big, or Bonneville Sagebrush.
- There is quite a bit of Aspen and Bigtooth Maple mix. Have these been over mapped?
- How does the Forest Shrubland type look?

<u>Soda Springs Ranger District:</u>

- There is quite a bit of Aspen. Have this been over mapped?
- Most of the sagebrush areas are classified as Mountain Big. Almost nothing is mapped as Wyoming Big, Basin Big, or Bonneville Sagebrush.

Montpelier Ranger District:

- There is quite a bit of Aspen. Have this been over mapped? Otherwise most of the forested areas were classified as Douglas-fir, Spruce/Fir mix and Lodgepole .
- There is quite a bit of Bigtooth Maple mapped on the south-western edge, along the Bear River Range.
- Most of the sagebrush areas are classified as Mountain Big. Almost nothing is mapped as Wyoming Big, Basin Big, or Bonneville Sagebrush.

Westside Ranger District:

- Most of the forested areas were classified as Douglas-fir and Aspen. There is more woodlands (Bigtooth Maple mix, Juniper mix, and Mountain Mahagony mix) than forest types. Is this OK?
- Most of the sagebrush areas are classified as Mountain Big. Almost nothing is mapped as Wyoming Big, Basin Big, or Bonneville Sagebrush.

Curlew National Grasslands:

- Is this map more accurate than the existing Curlew Existing Veg map? We were going to map just to the lifeform – shrub and herbaceous. The existing map was then going to be used to assign specific species/community types.
- Most of the shrublands were classified as Wyoming, Basin, & Bonneville Sagebrush and all of the herbaceous areas were classified as Ruderal Grasslands. There are approximately 89 acres of Juniper Mix.
- Riparian shrublands & herbaceous areas were photo-interpreted. Do these look OK?
- Do the burn areas look OK

Schedule & Contact Info:

Send back all hardcopy draft maps and associated comments/edits and shapefile edits by **August 6th** to:

Wendy Goetz
wgoetz@fs.fed.us
Remote Sensing Applications Center
2222 West 2300 South
Salt Lake City, UT 84119

If you have any questions contact:

Rose Lehman	rlehman@fs.fed.us	(208) 557-5788
Sanford Moss	swmoss@fs.fed.us	(801) 625-5219
Wendy Goetz	wgoetz@fs.fed.us	(801) 975-3841

References:

Brohamn, R.; Bryant L. editors. 2005. Existing vegetation classification and mapping technical guide. Gen Tech. Rep. WO-67. Washington DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 305 p.

Tuxen, R. 1956. Die heutige naturliche potentielle Vegetation als Gegenstand der vegetation-skartierung. Remagen. Berichtze zur Deutschen Landekunde. 19:200-246.

Appendix X: Merge Rules for Segments Less Than MMU Size

Caribou-Targhee NF
Merge Rules for Segments less than MMU Size

CT Vegetation Types:

- Aspen
- Aspen/Conifer
- Conifer/Aspen
- Douglas-fir
- Douglas-fir/Lodgepole
- Limber Pine/Douglas-fir
- Lodgepole Pine
- Spruce/Fir
- Conifer Mix
- Whitebark Mix
- Bigtooth Maple Mix
- Juniper Mix
- Mountain Mahogany Mix
- Forest & Mountain Shrublands
- Dwarf Sagebrush
- Mountain Big Sagebrush
- Wyoming, Basin & Bonneville Sagebrush
- Alpine Herbaceous
- Subalpine Herbaceous
- Montane Herbaceous
- Ruderal Grasslands
- Riparian Herbaceous
- Riparian Shrublands/Deciduous Tree
- Barren/Sparsely vegetated
- Agriculture
- Developed
- Water

Deciduous types	= AS, AS/C, C/AS, MPmix
Conifer types	= DF, DF/LP, LM/DF, LP, SF, Cmix , WBmix, Jmix, MMmix
Shrub types	= FMSH, DSB, MSB, SBmix
Herbaceous types	= ALP, SUBH, MTNH, RGR
Riparian types	= RHE, RSH
Barren/Sparse Veg	= BR/SV
Other	= AGR, DEV
Water	= WA

Deciduous & Forest Types (5 acres)

Aspen

1. Aspen/Conifer
2. Conifer/Aspen
3. Bigtooth Maple Mix
4. Conifer
5. Shrubland
6. Herbaceous
7. Riparian
8. Barren/Sparsely vegetated
9. Other

Aspen/Conifer

1. Aspen
2. Conifer/Aspen
3. Bigtooth Maple Mix
4. Conifer
5. Shrubland
6. Herbaceous
7. Riparian
8. Barren/Sparsely vegetated
9. Other

Conifer/Aspen

1. Aspen/Conifer
2. Aspen
3. Bigtooth Maple Mix
4. Conifer
5. Shrubland
6. Herbaceous
7. Riparian
8. Barren/Sparsely vegetated
9. Other

Douglas-fir

1. Douglas-fir/Lodgepole
2. Lodgepole
3. Conifer Mix
4. Conifer
5. Deciduous
6. Shrubland
7. Herbaceous
8. Riparian
9. Barren/Sparsely vegetated
10. Other

Douglas-fir/Lodgepole

1. Douglas-fir
2. Lodgepole
3. Conifer Mix
4. Conifer
5. Deciduous
6. Shrubland
7. Herbaceous
8. Riparian
9. Barren/Sparsely vegetated
10. Other

Limber Pine/Douglas-fir

1. Whitebark Pine Mix
2. Douglas-fir
3. Conifer
4. Shrubland
5. Herbaceous
6. Riparian
7. Barren/Sparsely vegetated
8. Other

Bigtooth Maple Mix

1. Aspen
2. Aspen/Conifer
3. Conifer/Aspen
4. Conifer
5. Shrubland
6. Herbaceous
7. Riparian
8. Barren/Sparsely vegetated
9. Other

Lodgepole Pine

1. Douglas-fir/Lodgepole
2. Douglas-fir
3. Conifer Mix
4. Conifer
5. Deciduous
6. Shrubland
7. Herbaceous
8. Riparian
9. Barren/Sparsely vegetated
10. Other

Spruce/Fir

1. Conifer Mix
2. Whitebark Mix
3. Limber Pine/Douglas-fir
4. Conifer
5. Deciduous
6. Shrubland
7. Herbaceous
8. Riparian
9. Barren/Sparsely vegetated
10. Other

Conifer Mix

1. Spruce/Fir
2. Whitebark Mix
3. Douglas-fir/Lodgepole
4. Conifer
5. Deciduous
6. Shrubland
7. Herbaceous
8. Riparian
9. Barren/Sparsely vegetated
10. Other

Whitebark Pine Mix

1. Limber Pine/Douglas-fir
2. Spruce/Fir
3. Conifer Mix
4. Conifer
5. Deciduous
6. Shrubland
7. Herbaceous
8. Riparian
9. Barren/Sparsely vegetated
10. Other

Juniper Mix

1. Mountain Mahogany Mix
2. Conifer
3. Deciduous
4. Shrubland
5. Herbaceous
6. Riparian
7. Barren/Sparsely vegetated
8. Other

Mountain Mahogany

1. Juniper Mix
2. Conifer
3. Deciduous
4. Shrubland
5. Herbaceous
6. Riparian
7. Barren/Sparsely Vegetated
8. Other

Shrublands (5 acres)

Forest & Mountain Shrublands

1. Mountain Big Sagebrush
2. Shrubland
3. Herbaceous
4. Deciduous
5. Riparian
6. Conifer
7. Barren/Sparsely vegetated
8. Other

Dwarf Sagebrush

1. Wyoming, Basin & Bonn. Sage
2. Mountain Big Sagebrush
3. Forest & Mtn Shrublands
4. Herbaceous
5. Jmix
6. MMmix
7. MPmix
8. Barren/Sparsely vegetated
9. Deciduous
10. Conifer
11. Riparian
12. Other

Mountain Big Sagebrush

1. Forest & Mtn Shrublands
2. Wyoming, Basin & Bonn. Sage
3. Dwarf Sagebrush
4. Herbaceous
5. Jmix
6. MMmix
7. MPmix
8. Barren/Sparsely vegetated
9. Deciduous
10. Conifer
11. Riparian
12. Other

Wyoming, Basin & Bonn. Sagebrush
1. Mountain Big Sagebrush
2. Forest & Mtn Shrublands
3. Dwarf Sagebrush
4. Herbaceous
5. Jmix
6. MMmix
7. MPmix
8. Barren/Sparsely vegetated
9. Deciduous
10. Conifer
11. Riparian
12. Other

Herbaceous (5 acres)

Alpine Herbaceous
1. Barren/Sparsely vegetated
2. Subalpine Herbaceous
3. Herbaceous
4. Shrublands
5. Riparian
6. Deciduous
7. Conifer
8. Other

Subalpine Herbaceous
1. Herbaceous
2. Shrublands
3. Barren/Sparsely vegetated
4. Riparian
5. Deciduous
6. Conifer
7. Other

Montane Herbaceous
1. Herbaceous
2. Shrublands
3. Barren/Sparsely vegetated
4. Riparian
5. Deciduous
6. Conifer
7. Other

Ruderal Grasslands
1. Herbaceous
2. Shrublands
3. Barren/Sparsely vegetated
4. Riparian
5. Deciduous
6. Conifer
7. Other

Riparian (2 acres)

Riparian Herbaceous

1. Riparian shrublands
2. Herbaceous
3. Shrublands
4. Deciduous
5. Conifer
6. Other

Riparian Shrublands

1. Riparian Herbaceous
2. Aspen
3. Bigtooth Maple Mix
4. FMSH
5. Shrublands
6. Deciduous
7. Herbaceous
8. Conifer
9. Other

Non-Veg

Barren/Sparsely vegetated (5 acres)

1. Alpine Herbaceous
2. Herbaceous
3. Other
4. Shrublands
5. Deciduous
6. Conifer
7. Riparian

Water (1 acre)

1. Riparian Herbaceous
2. Riparian Shrubland
3. Herbaceous
4. Shrubland
5. Barren/Sparsely vegetated
6. Deciduous
7. Conifer
8. Other

Agriculture (1 acre)

1. Herbaceous
2. Shrubland
3. Deciduous
4. Conifer
5. Other

Developed (1 acre)

1. Barren/Sparsely vegetated
2. Herbaceous
3. Shrubland
4. Deciduous
5. Conifer
6. Other

CT Canopy Cover Types:

- Tree canopy 1
- Tree canopy 2
- Tree canopy 3
- Tree canopy 4
- Tree canopy 5
- Shrub canopy 1
- Shrub canopy 2
- Shrub canopy 3
- Shrub canopy 4

<u>Tree Canopy 1</u>
1. Tree canopy 2
2. Tree canopy 3
3. Tree canopy 4
4. Tree canopy 5

<u>Tree Canopy 2</u>
1. Tree canopy 1
2. Tree canopy 3
3. Tree canopy 4
4. Tree canopy 5

<u>Tree Canopy 3</u>
1. Tree canopy 2
2. Tree canopy 4
3. Tree canopy 1
4. Tree canopy 5

<u>Tree Canopy 4</u>
1. Tree canopy 3
2. Tree canopy 5
3. Tree canopy 2
4. Tree canopy 1

<u>Tree canopy 5</u>
1. Tree canopy 4
2. Tree canopy 3
3. Tree canopy 2
4. Tree canopy 1

<u>Upland Shrub Canopy 1</u>
1. Upland shrub canopy 2
2. Upland shrub canopy 3
3. Upland shrub canopy 4

<u>Upland Shrub Canopy 2</u>
1. Upland shrub canopy 1
2. Upland shrub canopy 3
3. Upland shrub canopy 4

<u>Upland Shrub Canopy 3</u>
1. Upland shrub canopy 2
2. Upland shrub canopy 4
3. Upland shrub canopy 1

<u>Upland Shrub Canopy 4</u>
1. Upland shrub canopy 3
2. Upland shrub canopy 2
3. Upland shrub canopy 1

Riparian Shrub Canopy 1 (2 acres)

1. Riparian shrub canopy 2
2. Riparian shrub canopy 3
3. Riparian shrub canopy 4

Riparian Shrub Canopy 2 (2 acres)

1. Riparian shrub canopy 1
2. Riparian shrub canopy 3
3. Riparian shrub canopy 4

Riparian Shrub Canopy 3 (2 acres)

1. Riparian shrub canopy 2
2. Riparian shrub canopy 4
3. Riparian shrub canopy 1

Riparian Shrub Canopy 4 (2 acres)

4. Riparian shrub canopy 3
5. Riparian shrub canopy 2
6. Riparian shrub canopy 1

Tree Size Classes:

- Forest Tree Size 1
- Forest Tree Size 2
- Forest Tree Size 3
- Woodland Tree Size 1
- Woodland Tree Size 2
- Woodland Tree Size 3

Forest Tree Size 1

1. Forest tree size 2
2. Forest tree size 3

Forest Tree Size 2

1. Forest tree size 3
2. Forest tree size 1

Forest Tree Size 3

3. Forest tree size 2
4. Forest tree size 1

Woodland Tree Size 1

1. Woodland tree size 2
2. Woodland tree size 3

Woodland Tree Size 2

1. Woodland tree size 3
2. Woodland tree size 1

Woodland Tree Size 3

1. Woodland tree size 2
2. Woodland tree size 1